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INTERPLANETARY MAN?

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I. Introduction

It is with some hesitation that I address this very expert Society. I feel much as a man might feel who, merely because he once wrote a children's story about a magic carpet, has undertaken to discourse to a society of aeroplane designers about the future of aviation. Contributors to the *Journal* of this truly epoch-making Society overawe me with their scientific knowledge and their wealth of mathematical formulæ! Let me at once put my cards on the table by confessing that my training in science ended when I failed to pass the "London Matric" in what used to be called "organic chemistry," and that my knowledge of mathematics is far more sketchy even than my knowledge of the sciences. I am a dabbler in many subjects, an expert in none. As such, my only function to-night must be to bring to bear on interplanetary travel light from other fields of knowledge.

Modern civilization cannot get along without experts of many kinds. In most fields the day of the amateur is past. But just because this is pre-eminently an age of experts, we have to face the serious danger that the human race may come to consist wholly of experts none of whom understands what his fellows are doing, or why they are doing it, and all of whom are ignorant of the pattern of human life as a whole. Knowledge has become so vast that no single mind can speak with authority save in relation to his own particular corner of it. But such is the prestige of scientific expertism that scientists are apt to make far-reaching pronouncements about matters lying beyond their special competence, for instance about politics, ethics, religion and philosophy. One of the most serious problems of our day is to work out an educational technique which, while producing real experts in each field, will ensure that each one of them will also be a reasonably well informed and responsible democratic citizen. Even when this end has been achieved, it will still be necessary for some people to tackle the work of correlating the various growing points of thought. This is supposed to be the task of philosophers, or of one particular sort of philosophers. They have to learn something from all the main kinds of experts, and to relate the findings in each field to the findings in others. This is indeed a formidable task; and unless these universal intruders combine intelligence with humility, they are likely to make a mess of it, and to be reviled by the experts in every field.

It is therefore with a combination of humility and the hardihood that leads fools to rush in where angels fear to tread that I venture to talk to you at all. The only useful thing I can do is to try to show you how, as it seems to me, your bold and highly specialized venture of interplanetary travel fits into the total venture of man in this formidable universe.

I start with an assumption amply justified by the Society's work. I assume that, if all goes well with man, men will, in fact, be able to reach the other planets within a few decades, and able to effect landings on them. This assumption may, of course, turn out to be unjustified. Unexpected difficulties may arise. Or, on the other hand, all may *not* go well with man. His folly may quite well lead to the destruction of civilization, to the extermination of his species, and even to the extinction of all terrestrial life. It is not entirely fantastic to surmise that he may even blow up his planet, and reduce it to a new swarm of asteroids. In gaining control of atomic energy, man clumsily grasps an instrument of incalculable potency, both for good and for evil. J. B. S. Haldane has suggested that it may be a law of nature that any species that gains atomic power before unifying its world-society must destroy itself. I should myself say, not merely "before it unifies its world-society," but "before it disciplines itself to the true values."

Probably there has never before, in the whole career of our species, been so momentous a crisis as that of our day. Our own human species is said to have begun about a quarter to half a million years ago. For most of this period the river of human life has wandered sluggishly through the plains of time. If we consider the average length of a human generation over this period to be about twenty-five years, then some twenty thousand generations have passed since *Homo Sapiens* began. During almost the whole of that vast period (perhaps a four-thousandth part of the aeon that has passed since the earth's formation) men had little power, and change in human affairs was very slight. Tribes, no doubt, rose and fell. Improvements in technique were rarely discovered; and discovered only to be lost again, and re-discovered ages afterwards. Conditions in a man's childhood were generally much the same as conditions in his old age. But at last this slow and tortuous advance in the techniques of production achieved agriculture, and later the building of cities, the founding of civilization. This seems to have occurred some six thousand years ago, or a little over two hundred and forty generations. The river of human life accelerated somewhat, tumbling forward in rapids. Power and leisure and comfort increased; but almost always only for the few. The masses seem to have been more and more deeply enslaved. Not till almost the end of this six thousand years, say three hundred years ago or about twelve generations, did modern science begin to take effect on human life. Thus man has used science only during the last thousandth part of his whole career, and his career is the last four-thousandth of the period since the earth was formed. In our own day, man is snatching at atomic power. We are the first generation of the atomic age. Change is already far more rapid than ever before, and will soon become catastrophic, for good or ill. The river of human life has reached a precipice. The cataract plunges—whither? It is quite possible that we may be the last of all human generations. Yet, barring

accidents, the earth should be habitable for a period as long as it has yet existed, say two thousand million years, or some eighty million of our present human generations.

There seem to be three possible futures for man: (1) actual and speedy annihilation; (2) the creation of a world-wide totalitarian ant-state, based on atomic power and the reduction of all human individuals to robots; (3) the founding of a new kind of human world, in which the Aladdin's lamp of science will be used wisely, instead of being abandoned to that blend of short-sighted stupidity and downright power-lust that has played so tragic a part in the application of science thus far. It is a platitude that man has gained power without wisdom. If he does not at the eleventh hour, or half a minute before zero hour, become just a little less silly, his doom is sealed. On the other hand, given a modicum of wisdom, we shall be able greatly to raise the conditions of life for all human beings, no matter what their colour, and to afford to every one of them the chance to develop and express such capacity as he has for truly human living and truly human work in the great common enterprise of man. What that enterprise is or should be, I shall consider later.

This possibility of affording to all men full opportunity is now no merely Utopian dream. Its progressive attainment is at last physically possible. Nothing now stands in the way but the ignorance, the stupidity and the evil will of men. And let me say at once, though I shall later enlarge on this point, that the promise is not simply one of increased luxury and hoggish ease. Rather it is a promise of a deepening and enriching of human experience. Man's present condition of constant frustration and torment and fear makes most men to-day think only in terms of the hope of luxury and security. But if ever we do successfully turn our present dangerous corner, and a generation appears that is freed from crippling conditions, then men's minds will at last be able effectively to desire something more than mere luxury and security. Be sure, also, that in the promised world there will be no lack of challenge and danger and even tragedy. The novelty will be rather that man will have outgrown at last the diseases of mere infancy, and will be able to enter for the first time into the more dangerous, more troubled, but ampler and richer and more conscious life of adolescence.

II. If the Planets are Inhabited

At this most critical moment of human history man finds himself on the very threshold of a new freedom, the freedom to travel beyond the terrestrial atmosphere and explore the whole solar system. What should he do with this new power?

Much depends on the conditions of the planets that he visits. Two possibilities must be noted. Either man will find elsewhere in the solar system other intelligences, or he will not. If he does, then again there are two possibilities. One is the possibility of wars between the worlds. This situation might perhaps cause at least a temporary unification of mankind in face of the common danger, much as Russia and the West united against Hitler. The War of Worlds would be followed either by man's defeat and

ruin or by his victory, and then by exploitation of the conquered races for man's advancement. The other possibility is interplanetary co-operation. But in view of our sad inability even to unite mankind, it seems extremely unlikely that man in his present state would succeed in co-operating with alien races on other planets. Far more likely is it that the rival imperialisms and ideologies of this planet would be extended to struggle against each other in other worlds, tyrannizing over and ultimately destroying the native peoples. If, on the other hand, man does soon succeed in unifying his world-society, then it is at least conceivable that some kind of mutually profitable symbiosis with intelligent races on other planets might be established.

On the whole, however, it seems unlikely that any of the other worlds within the solar system is inhabited by any race even approaching man in intelligence. Bear with me while I summarize the data, and correct me later if I am mistaken. Let us begin with our nearest neighbour, the moon. I am told that it is almost wholly without atmosphere and water. There seems to be no reason at all for supposing that it has, or ever did have, intelligent inhabitants. Of the planets themselves, Mercury is far too hot on one side and far too cold on the other. Venus is more temperate, and has a copious atmosphere; but apparently it lacks oxygen, and would not support life such as we know on our own planet. Water also may be lacking. Mars, owing to its feeble gravitation, has already lost most of its atmosphere and most of its water. Indeed, its polar caps may turn out to be composed of carbon dioxide snow, or something worse. However, there is considerable evidence that vegetation of some sort does exist on Mars; but certainly no convincing evidence of the artifacts of an intelligent race. Probably the process of biological evolution on the planet was less rapid than that of the earth, since on the whole, the larger the geographical field, the greater the chance of the occurrence of a wealth of varieties on which natural selection could work. Further, the evolutionary process was probably cut short or greatly retarded by the rapid deterioration of conditions. On the whole, then, it seems unlikely that on Mars life (such as we know) has evolved to the human level. The asteroids are of course much too small. On the other hand, Jupiter and Saturn, and probably all the outer planets, are too big, and have apparently quite the wrong kind of atmosphere for life of the terrestrial type.

Of course, we cannot entirely reject the possibility that on some of the planets life has evolved on a different chemical basis, and that atmospheres lethal to us may be hospitable to biochemical processes alien to ours. But I understand that terrestrial life depends on the unique diversity of the carbon compounds, and that, though a biochemical system based on some element other than carbon is not possible, it would have a far smaller range of compounds, and so the scope of its biological evolution would be very restricted. However, we should not dismiss the possibility that Jupiter or some other great planet is inhabited by minute intelligent creatures whose constitution is quite unknown to us. The evidence is opposed to this view, but not overwhelmingly.

At this point I cannot resist a digression, and indulgence in the wildest fantasy. Fundamentally life seems to consist of a utilizing of some particular

form of the general process of the increase of entropy so as to gather power for the maintenance of vital activities. Life taps and canalizes part of the vast spate of energy, thus forming a "mill-stream" by which its own little "water-wheel" may be worked. Well, might there not be living creatures based not on chemical action but on the energy released by the disintegration of atoms? Might there not be, not on any planet but in the sun's turbulent outer layers or in its middle depths, flame-like organisms of this type, and might not some species of them equal or excel man in intelligence? This is indeed a flagrant digression from the purpose of this paper, for it seems quite impossible that man should ever in his space-ships invade the sun and make contact with such incandescent beings.

To return to our subject, it seems very unlikely that there is any intelligent race anywhere in the solar system, except mankind. Mars is the only planet that should make us hesitate to accept this conclusion, but in this case too the betting is heavily against any highly developed life.

III. If the Planets are Uninhabited

If man finds the planets uninhabited, what should he do with them? If mankind is still disunited, no doubt there will be a race between rival imperialisms to annex those vast virgin territories. The coming struggle between America and Asia, with Europe as a battlefield, might well spread to Mars. Already one of our vigorous but still culturally adolescent cousins across the Atlantic is reported to have suggested that the moon should be annexed as soon as possible as an industrial field for American exploitation. Alas! Must the first flag to be planted beyond the earth's confines be the Stars and Stripes, and not the banner of a united Humanity?

In passing, let us remind ourselves that merely to circumnavigate a planet does not necessarily imply the possibility of landing on it and walking about, let alone staying there and undertaking any sort of survey or industrial operation. Clearly the pioneers would have to be equipped not only with food and water and air for their journey but with pressure-suits, oxygen and an ample water supply for their stay on the planet. And as things stand, they might also need weapons to defend themselves from attack by emissaries from rival terrestrial states.

But let us suppose that mankind has at last become effectively united, both politically and socially. Then what should a united mankind do with the planets?

Obviously, the first thing to do would be to explore them. Sheer scientific curiosity would certainly insist on thoroughly surveying them. They would offer the kind of lure that was offered in the nineteenth century by Darkest Africa, the north and south poles and the unclimbed Himalayas. Bold young people would be very ready to give their services for planetary exploration. Their effective motive would probably be sheer adventure, though the rational justification of such costly and dangerous undertakings would of course be the advance of science. It is conceivable, however, that everything really significant about those desert worlds might be learned by merely circumnavigating them without landing on them. Perhaps men will be so absorbed in

the general advance of science and in the exciting task of creating a really adult human society on earth, that they will simply never bother to take the necessary trouble to set foot on another planet. No doubt this is unlikely, because the irrational, romantic glamour of opening up unexplored worlds will be too strong, even if those worlds turn out to be inhospitable and dreary wastes.

Apart from the motives of sheer curiosity and sheer adventure, the obvious motive for exploring the planets is the hope of discovering immense fields of natural resources, and exploiting them for human welfare. They might, for instance, yield valuable stores of uranium or other sources of atomic power, or any of the rarer elements or minerals needed by man. I am quite incompetent in this field, and must merely note that the motive of economic gain may play a leading part in man's dealings with the planets.

Let us admit, however, that it would be far best for man to postpone his exploitation of alien planets until he had concentrated seriously on improving terrestrial conditions. Equipped with highly developed scientific knowledge and atomic power, he should first undertake the comparatively easy task of turning his native planet into a more convenient and more delectable home. Climates might be improved, coastlines modified, deserts irrigated, jungles tamed, mountains (where they happened to be obstructive) blasted out of the way. Mineral wealth might be brought up from the depths of the terrestrial globe, Antarctica and the great Arctic Islands might be warmed and colonized. And so on. But let us hope that none of these vast enterprises will be attempted till mankind has attained a rather higher level of wisdom, and has a clear knowledge of the kind of world that would really favour human development. For my part, since I am by nature something of a savage, I cannot help hoping also that many regions will be preserved in their wild state for the recreation and refreshment of a species which, after all, is biologically adapted to a primitive environment.

But however desirable this reconstruction of the earth's surface, sooner or later for good or ill, a united mankind, equipped with science and power, will probably turn its attention to the other planets, not only for economic exploitation, but also as possible homes for man. Perhaps the most promising is Mars. If the venture seemed really worth while, that small cold, arid world might be rendered at least habitable, if not a paradise for man. All the necessary materials would be present in the crust of the planet itself. Human ingenuity, with atomic power, should be able to increase the atmosphere and the water supply, irrigate the desert surface, produce a suitable vegetation, and even raise the surface temperature. Whether this huge undertaking would be in fact worth while or not, is a question which I shall consider later. At present I suggest merely that it probably could be accomplished. In frivolous moments one feels that Mars might be used as an extra-terrestrial "Siberia" in which to exile all our really tiresome people. But I fear that the little planet would soon be overcrowded, and Earth depopulated.

Like Mars, the moon could perhaps be rendered distressfully habitable by terrestrial man; though in this case, presumably, the artificial atmosphere would escape far more rapidly, and would need to be constantly replenished.

Incidentally, much of it would be drawn off by the Earth, thus complicating our terrestrial problems by increasing our atmospheric pressure.

What of Venus? The task would probably be much more formidable. From the little that we know of Venerian conditions, it would seem that the first problem would be to alter the composition of the already existing atmosphere, which, so far as is now known, is quite unsuited to terrestrial life. And water, if indeed it is absent, would have to be created in bulk. Then we should have to produce a vegetation for the maintenance of a supply of free oxygen. But on the whole, though Venus offers a more difficult problem than Mars, it might in the long run become a more satisfactory home for man. It is much larger, and of course far warmer. Instead of affording the human colonists a distressful and precarious existence, it might in time rival and surpass the Earth as a home for intelligent beings.

The greater planets would seem to offer no possibility of human colonization, owing to unfavourable atmosphere, chilly remoteness from the sun, and such gravitational pressure that a man's body would be an insupportable burden.

IV. Adapting Man to the Planets

It is time to approach the whole matter from another angle. If the mountain will not come to Mohamet, Mohamet must go to the mountain. If the planets are unadaptable to man in his present form, perhaps man might adapt himself to the alien environments of those strange worlds. Or rather, perhaps a combination of the two processes might enable man to make the best possible use of those worlds. In fact, given sufficient biological knowledge and eugenical technique, it might be possible to breed new human types of men to people the planets.

Once more, Mars seems to offer the best opportunity. It should be fairly easy to produce a variety of *homo sapiens* capable of surviving the rigours of an improved Martian environment. Perhaps the best human stock from which to start would be the Tibetans, who are used to a cold, arid climate and a rarified atmosphere. But unless the Martian atmosphere could be augmented quite a lot, and the surface temperature greatly raised, the specialized human Martians would probably lack the vital energy for any kind of highly developed civilization. Only where nature blossoms with a certain luxuriance can the human spirit itself blossom. However, by a combination of environmental and eugenical alteration, it might perhaps be possible in the long run to establish a vigorous population on Mars.

On Venus, given oxygen and water, man's biochemical and eugenical technique might perhaps produce a well-adapted human variety or a new human species. Since Venerian man would have to stand great heat, the work might start with experiments on some Equatorial varieties of our species. Presumably in that hot world a dark skin would be useful; unless, indeed, permanent shade was maintained by a cloud-blanket over the whole planet. There would certainly be a tendency for a large proportion of the planet's water to remain permanently suspended in the atmosphere.

On the outer planets, eugenics would have to play a major part. Even if the problems of the atmosphere and the extreme cold could be solved, there

would be very great difficulties to face. It would be necessary to create a specially adapted human species of very small stature to cope with the excess of gravitation. This might well involve a serious reduction in the size of the cerebral cortices, with a consequent reduction of intelligence. For intelligence seems to depend on the actual number of top-level cells in the nervous system; or, as it were, on the complexity of the telephone exchange. Thus the attainment of human intelligence in a very small mammal would be impossible, unless some way could be found for greatly reducing the size of the individual cells and the thickness of the fibres without impairing efficiency. There is one other conceivable way out of the difficulty. By very drastic eugenical operation on the existing human form, it might be possible to enable the present human brain to be supported, in spite of excessive gravitation, by throwing man into the quadruped position, greatly strengthening the four legs, and at the same time pushing the head far backwards so as to distribute its weight evenly between the fore and hind legs. But what of the problem of providing hands? The fore-limbs would be fully occupied and unavailable for manipulation. My only suggestion is that the nose might be greatly elongated into a trunk, equipped with delicate grasping instruments like fingers. It would probably be desirable to have two trunks, if not three. The eyes, by the way, would have to be projected well forward from the thrown-back brain-pan, otherwise *Homo Jovianus* would not be able to see where he was stepping.

Enough has been said to suggest that the colonization of some of the planets may in time become practicable, if terrestrial man continues to develop his control of the physical environment through atomic power, and if he attains sufficient biological knowledge and eugenical art to breed, or otherwise construct, human or quasi-human races adapted to strange environments.

But a word of caution is necessary. It is extremely important that none of these eugenical ventures should be attempted without thorough knowledge of the probable indirect results of each proposed change. For instance, it would be disastrous to aim at very small stature without doing something to avoid reduction in intelligence. Further, it is necessary to have very clear ideas as to which human characteristics are unimportant and might be safely sacrified, and which are indispensable and should never be endangered. Thus good vision, high intelligence, co-operativeness and manual dexterity are indispensable and should if possible be increased; while teeth and cranial hair could if necessary be sacrified. The result of thoughtless "messing about" with human nature might be the psychological and spiritual ruin of man.

V. What is it All For?

This brings me at last to the real crux of my subject. Would there be any point in colonizing the planets? What are we getting at? What is it all for? Why not just stay put on our native planet and muck along as before?

Broadly, there seem to be three possible motives that might control man's dealings with the planets. (I exclude scientific curiosity, which, though it might be an important motive with some individuals, is not likely to be the determining factor.)

First, the physical resources of those worlds might be exploited simply in order to increase the luxury of human beings on earth. This aim might involve the creation of industrial settlements on the planets, but it might not involve large-scale colonization. The policy would be simply to use the planets to afford to human beings as much pleasure as possible, to give to all of them the greatest possible affluence; in fact, to create a society in which every individual would have the privileges that only millionaires have to-day. Drudgery would be completely abolished. All manner of superfine food and drink, and all manner of ingenious amusements would be constantly available at the cost of merely pressing buttons or switches. Not only the "movies" but also the "feelies" and "smellies" and "sexies" would provide unending beatitude, in the manner foreseen by Aldous Huxley and others. Any subsequent boredom or lassitude would be at once corrected by means of fresh interests or appropriate drugs. No-one would ever do anything unpleasant or uninteresting. Machines of all sorts would be the tireless and obedient slaves of every man. All men would be aristocrats in the worse sense of the word, not the better. All would be pleasure-addicts, accustomed to every luxury; spoilt children who, through being shielded from the sterner possibilities of life, would simply never grow up. Of course, *before* the attainment of this strictly hedonistic Utopia, many men would have had to live laboriously and dangerously and devotedly, in the cause of science and exploration and invention, in order to make such a luxury-world possible. But once the new order had been thoroughly established, it might maintain itself perpetually with a minimum of direction of human action.

Most of us, I think, would agree that, though a certain amount of luxury is a harmless and even civilizing thing, there is a point beyond which the increase of luxury leads to spiritual degradation. Man has risen by versatility and intelligence. If he were to enter at last upon a stable condition of perfect adaptation to an unchanging environment, he would gradually lose his distinctive powers. Intelligence would atrophy. The world-society might perhaps survive unchanged for millions of years; but sooner or later man would be confronted with some new challenge from the environment, and would have lost the wit to cope with it. I conclude that if the fruit of all the devotion of the British Interplanetary Society is to be merely the debauching of mankind with the riches of other worlds, you had better all stop paying your subscriptions.

The second possible aim in relation to the planets is simply to increase man's power over the environment, and to extend that power so as to tackle fresh environments.

In the heyday of the industrialization of Europe and America, power did seem to many people an end in itself. The craving to leave one's mark on the environment, any sort of mark, so long as it is *my* mark, made actually by me, is very strong in a certain type of uncultured mind. Human animals carve their initials on trees, rocks, school desks and public monuments. They deface beautiful objects simply for the lust of power. They satisfy their primitive impulses for construction thoughtlessly, without regard to the

remoter consequences; sometimes harmlessly, but sometimes disastrously in ways that are less *con*structive than *des*tructive. Children harmlessly make mud pies or play with meccano sets. Adults less innocently build empires or great commercial ventures. Generally some fairly plausible excuse is found for all this feverish activity. The mud pies are magic castles; the empires, instruments of civilization; the commercial ventures, purveyors of comfort or luxury. But at bottom the motive is often simply the insatiable itch to make a mark on the environment, any old mark, but the bigger the better. In itself, the impulse is harmless, even worthy; but we have to learn to make our mark in inoffensive and if possible actually useful ways.

More precisely, the itch to leave a mark is quite wholesome, on condition that, even if it does not actually serve some higher aim, at least it does not positively hinder proper development. It must not be allowed to degenerate into mere obsessive doodling or meddling on however vast a scale. The danger for mankind as a whole is that, having solved its present urgent problems it will slip in to the assumption that the goal of all its corporate action is simply to make a bigger and bigger mark on a bigger and bigger environment. Power is all too apt to become an end in itself. In the old days self-assertive individuals aimed at local tyranny or world empire. Henceforth they will be more likely to dominate either through money power or through fulfilling important functions domineeringly in a highly organized state, perhaps a world-state of totalitarian type. It has been said that power corrupts, and absolute power corrupts absolutely. Those who control the world-state, whether it is capitalist or communist or social-democratic, will be in danger of grave corruption unless they are imperturbably orientated to the true values. They will readily idealize their own power lust, and persuade mankind that the right goal for man is simply dominance over the environment. And so in time the planet may approximate to Aldous Huxley's *Brave New World*, in which society is organized to the extreme pitch of efficiency with the aim simply of producing as much as possible. In that horrid world the workers are given unlimited easy pleasure, while the élite, the bureaucrats and technicians, have the satisfaction of directing the whole life of society.

If the future terrestrial society is organized on these principles, then the other planets will be used for the same end. Ostensibly the aim will be to use them as sources of raw material for man's comfort and luxury, on this planet or others; but behind this orthodox economic motive will lie the unacknowledged motive of sheer power. And if individuals can be corrupted by power, so can a whole species. Man may become obsessed with a passion merely to make a big mark on the solar system. In principle there is no difference between this aim and that of the urchin who sets fire to the heath or throws stones at windows.

The third possible motive for gaining control of the planets is that of using them to make the "most" of man, or the "best" of him; in fact, for the full expression of the most developed capacities of the human species. Here we have a goal which, though extremely vague, is more promising. What does it really imply? Broadly, it may be interpreted in two different ways, one purely humanistic, the other involving a reference to something over and

above man, though it is known to us mainly through its imperfect manifestation in man himself. The question to be faced is this. Are we justified in regarding man *simply* as an end in himself? Is "good" *simply* whatever man wills? Is a thing to be called "good" merely *because* or *in that* man wills it? Or, on the other hand, is man to be regarded rather as a means to an end, an instrument for the fulfilling of an end that is in some sense independent of his actual nature in its present stage of development? These questions cannot be even clearly stated, let alone answered, without raising very difficult philosophical problems. They cannot be truly answered with a plain "yes" or "no." Rather the answer must be of the type, "In one sense man is an end, in another sense not an end but an instrument." In the same manner the physicists may justifiably say that in one sense an electron is a particle, and in another sense not a particle but a train of waves.

VI. Fundamental Values

Perhaps we shall be able to form more precise ideas on this subject (which really does concern an interplanetary society) if we try to answer the question, "What is man?"

Clearly, whatever else he is, he certainly is (or has) a body, which is a physical or electromagnetic system of protons, electrons, etc. J. B. S. Haldane (I think) remarks somewhere that the human body contains some millions of millions of millions of millions of hydrogen atoms, and corresponding amounts of other elements. Julian Huxley (I think) has pointed out that man's body is approximately half-way in size between an electron and the whole universe. Astronomically, man is very small, an inconceivably minute parasite on a minute planetary grain floating in an immense void that is extremely sparsely sprinkled with great suns. Size is in itself of no importance; but if in the minute human body the physical can be the vehicle of some degree of mind or spirit, how great may be the mental and spiritual capacity of the whole cosmos of star-systems!

Biologically, man (as we have already noted), or rather our own species of man, which we have ludicrously called *Homo Sapiens*, is of very recent growth. But he is the most developed of terrestrial organisms. That is, he is objectively the most complex, integrated, versatile. He has specialized in being unspecialized. Hence his remarkable adaptability, and his dominance over all other species. He has indeed made a bigger mark on this planet than any other species, and a much more complex and purposeful and organized mark. Basically he remains just a mammal, a primate. His unique gift is his relatively high intelligence, which has depended on the unique development of hands and eyes and cerebral cortices. There is good reason to believe, however, that man is a very imperfect species. The bird is just about perfected for its appropriate life, for flight in the terrestrial atmosphere; but man, though he has powers far beyond the range of the bird, has not perfected those powers. In his appropriate medium of intelligent purposive action, abstract thought, personal sensibility and artistic creation, he is little better than a clumsy flying lizard.

Psychologically, what is it that distinguishes man from the sub-human creatures, even from his nearest relatives, the apes? He has the same ground plan of organs, reflexes, innate behaviour and emotional reaction. He shows fear, aggression, self-regard, sexuality, gregariousness, curiosity, manipulative meddlesomeness, and so on. What is distinctive in him is his superior power of discrimination, of attending to likenesses and differences. Hence his native intelligence, by which I mean the power of solving *novel* problems, not to be solved by instinct or by established habit. This unique aptitude for discrimination and intelligence has opened up for him vast new universes or experience, impossible to any other terrestrial creature. All intelligence involves the power of attending to the relevant while ignoring the irrelevant. Hence, in man, comes the power of abstraction, of attending to a particular character and relating it to other instances of the same character, and giving the identity a name, such as "red," "two," "pleasant." Hence language and all the worlds of abstract thought and of concrete poetry.

Man's great power of concentration of attention has been applied not only to the environment but also to his own nature. Thus he has developed the possibility of a unique kind of self-awareness and awareness of other selves. In fact, he has become capable of personality, and of genuinely personal relationships, including all the forms of developed loving and hating. From this has arisen a distinctively human or personal kind of sociality. In sub-human animals, sociality is no more than a combination of the impulse of gregariousness (including self-abasement to the herd) and the impulse of self-assertion, rising to dominance over the herd. Of course, human beings themselves often behave in this sub-human way, but the distinctively human or personal way is something of a different kind, in that it involves respect for the other as a conscious person. The distinctively human society is best understood by considering the nature of genuine human love, which again is beyond the range of sub-human consciousness.

When John *really loves* Jane, he does what no beast can do. He does not *merely* have a pleasant glow of feeling about her. Of course he has this, but something more also. He is aware of her as a conscious being, distinct from himself, and different in character and needs and capacities. He accepts her as she is, without wishing to impose his will on her. He respects her as a person, takes responsibility for her, cherishes her, depends on her, is mentally enriched by knowing her and loving her, and is profoundly moulded by her. The two together form a little society of distinct beings united in mutual love, and cherishing not only each other but also the "we" that they together form. No doubt they also remain self-regarding individualists, and their self-interests often conflict. All love is complicated by hate. But in genuine love the conflict is largely transcended in the will for mutual adjustment and mutual dependence.

Perhaps I ought to apologize for wandering so far from the planets. But, believe me, this digression is very relevant to my theme. If one undertakes to discuss what man ought to do with the planets, one must first say what one thinks man ought to do with himself. And that is what I am trying to do. It cannot be done without a certain amount of fundamental thinking,

not in the way of theorizing about the universe, but through trying to get a clear view of human experience itself.

Well, to continue this venture, from the experience of love or friendship or some form of genuine community in the field of personal contacts, the human individual may rise to the will for genuine community in *all* his dealings with his fellow human beings, no matter how slight his contact with them. Thus arises the ideal of universal Christian love, or the brotherhood of man. This ideal has haunted man for thousands of years. In one form or another, it has played an important part in all the great religions of the world. In Christianity, love is deified. God, we are told, actually is, in some obscure way, Love. The Holy Spirit is Love. And love is believed by Christians to be the fundamental power which created the universe. To believe such a proposition seems to me to go far beyond the legitimate scope of human thinking; but the fact that in the past many of the best minds *have* believed this has to be taken into account.

Why is it that love, kindness, fellowship, genuine community between persons, in fact, the distinctively human or rather personal kind of sociality, has been so greatly praised? Obviously it has survival value. And if you are determined to explain the most developed kinds of human experience and behaviour, *simply* in terms of the social conditioning of primitive impulses, quite a plausible explanation can be given. But this explanation does not go to the root of the matter. It is sheer dogma that the most developed and conscious human experience and behaviour can be fully explained simply in terms of its primitive sources. To do so is to leave out the most distinctive thing about man, namely his power of standing outside himself, to some extent, and being interested in things other than himself for their own sake. Anyone who has really been in love should understand this. Anyone who has had any genuine religious feelings should know it even better. The great Saints, Western and Eastern, were concerned (I should say) with experiences at the highest reach of human capacity, experiences which cannot be adequately described in terms of merely primitive impulses. I would add that neither should we accept uncritically the saints' own interpretations of their experiences, stated in terms of their own contemporary ideas about the fundamental nature of the universe. Human language and human thought itself were not then, and are not even now, sufficiently developed to make reliable statements about those most fully "awakened" experiences. Nevertheless, the experiences themselves, I suggest, are extremely important for anyone concerned with the proper ordering of human life. Someone may protest that, however important these experiences were to the saints, they are of no importance to us, because we do not share in them. The objection is worth answering. No doubt the saints had religious experience in a peculiarly vivid and compelling form which most of us cannot attain. But even ordinary men and women, or at any rate the more sensitive of them, if they take the trouble to discipline themselves a little, and concentrate their attention on their felt relation with each other and with the universe, can quite well discover in their own experience the *kind* of thing that the great mystics were trying to describe.

For lack of a better term, I shall call this most significant kind of experience

"spiritual experience" or "experience of spirit." But I hasten to add that the word "spirit" need not be taken to mean some *thing* or *substance* other than matter, which is conceived as another thing or substance. Still less must spirit mean a divine person or God. I mean by "spirit" simply a particular way of experiencing and behaving. In fact, it is that kind of life which Christians sometimes call "the life of the spirit" or the "Way" of the Spirit, and Chinese sages have called simply "Tao," the "Way." What kind of a life the spiritual life is, I shall consider presently, trying to describe it in modern language and in relation to modern experience.

Meanwhile, I suggest that whatever *theories* men invent to justify the goodness or rightness of that way of life, what actually confronts them in their direct experience is simply a vision of the Way itself as supremely right. Whatever the status of spirit in the universe, what matters is simply spirit. The saints and sages yearned for the full expression of spirit in their own lives and the lives of others. They yearned to outgrow, or wake up from, the life of mere self-interest. They sought the ampler view. They sought, through self-denial, a real self-detachment for the sake of the ampler view, the deeper, more penetrating view. Through the discipline of the ordinary self-interested worldly self, they sought to "wake up," and adopt the point of view of a supposed universal self. Sometimes they persuaded themselves that they were actually gathered up into that supreme self in mystical communion; but even if one feels very sceptical about this, and about the existence of such a universal self, one must recognize that what they strove for was a transcendence of the limitations of mere *self*-concern, a self-forgetting through concern for other individuals and for the whole universe. In fact, a vision of the spirit as an ideal way of living, and as in some sense what we are *for*, intruded into their ordinary experience and claimed their allegiance.

But what *sort* of a way of life is the spiritual life? Leaving out the intellectual trappings of religious and metaphysical doctrine about the universe and fundamental reality, and bearing in mind aspects of knowledge that were not available to the ancients, I think we can express the essence of the matter in modern language. The very brief account that I shall give would not satisfy the ancient teachers or their modern followers, just because it leaves out the metaphysical doctrines; yet it does seem to me to describe the essence of their experience, in so far as it can have any meaning at all for ordinary human beings.

I must begin with a few words about the nature of personality, for the spiritual way is essentially a way for personal beings. Something is aware of something. "I," whatever that is, am aware of my body in its physical environment, and also of my "self" or psychological personality (as a creature with a certain character, needs and capacities), also of other persons, of societies of persons, of abstractions such as physical laws and moral principles, and (in a very sketchy way) of a whole objective universe *in* which I am. No doubt my awareness of these things is very confused and erroneous, but we all assume that there is *something* to be aware of, something which is independent of our experiencing it. In fact, there *is* an objective universe.

Now the innermost ring of objectivity, so to speak, is my own body in its relation with a physical environment. My body is experienced as a going concern, as dynamic, as tending toward certain actions and needing certain things of the environment. I consciously "espouse" my body's needs. I desire their fulfillment. For instance, when my body needs food, I desire the activity of eating. Similarly with the needs for sleep, sexual activity, and so on. In infancy this innermost ring of objectivity is all that is experienced. But gradually the growing child becomes aware of another ring of objectivity, namely that of conscious persons. He begins to be self-conscious and other-conscious. He "espouses" the needs of his own psychological person, and (less constantly) of a few other persons, such as his mother. In genuine love we "espouse" another person, forming a psychological symbiosis with him or her. The important point is that both the other person and my own self, with its particular character and needs and powers, are facts objective to my awareness of them. Of course, my awareness of them may be largely erroneous, I may make mistakes about them, as about any other objective facts. But they are not just fancy. They are what they are.

Beyond the sphere of the persons with whom I have personal contact, we may place another ring of objectivity, namely that on which occur all societies of persons, and the incipient society of mankind as a whole. Beyond again, comes the ring of abstract ideas, true and false, both kinds being objective to the experiencing "I." True ideas, in the final analysis, are simply objective characters apprehended by minds, and abstracted from their particular settings. The idea "dog" is the common character distinctive of all dogs. Of course, all ideas are partly false, some more so, some less. But even the false elements in ideas are rooted in objectivity. So to speak, they result from "squinting" objective characters together in wrong patterns, much as the drunkard may see two moons instead of one. He sees one moon twice, or in two places. Consider the idea of a "centaur," half horse, half man. There's no such beast; but the idea "centaur" is the product of "squinting" half a man and most of a horse together, and so forming a new abstract idea.

Now the overwhelmingly most important abstraction is the spirit, the ideal way of life. It is an ideal which is implied in, and emerges from, the actual experienced nature of personal beings, much as the law of gravity is implied in and emerges from the actual experienced nature of the behaviour of falling objects and the movements of planets and stars.

In the same way the ideas of good and evil and all possible kinds of values arise out of the impact of some region of objectivity on the conscious individual. Mere abstract subjectivity is no more than a featureless possibility of being aware of something, including values. All values arise from the conscious "espousal" of objective needs. Some are needs of one's own body, some are the more subtle needs of persons, myself and other selves.

Note further that personality *involves* community. There cannot be true personality save in true community with other persons. By community I mean not simply a relationship in which each individual strives to use others for his own advancement but the distinctively human social relationship, in

which individuals are united in mutual respect for each other *as persons*. The spiritual way is essentially a way for persons in community with other persons. As Christians might put it, it is the way for a "Church," not simply for the individual, seeking individualistic salvation. As Communists might put it, it is the way for comrades working devotedly in a common cause.

Now I suggest that the spirit is essentially the way of life in which we strive towards full, comprehensive and true awareness of the objective universe, and toward appropriate feeling and appropriate creative action in relation to it. The universe, of course, includes oneself as an object, a self among other selves. In the spiritual life one strives for sensitive and intelligent awareness of things *in* the universe (including persons), and of the universe *as a whole*. One strives also for appropriate feeling about things and people and the universe as a whole, without prejudice in favour of oneself as an individual or one's own family or nation, or even the human species. Finally one strives for appropriate and creative action in relation to all this.

The experience of the spirit, as the supreme good and as in some sense what we are "for," needs no support from metaphysical argument or religious doctrine. It is simply "given," as a datum, to the relatively awake mind, or rather to the awake mind that has not been perverted by obsession with some minor good, such as power, or bemused by some particular theory, such as materialism or theism. Let us never forget that, if theism is a frail invention of the human intellect, so is materialism. All such ambitious theories are almost certainly more false than true. All such metaphysical speculation, though interesting and educatively valuable, is quite unreliable, whether as support or denial of the experience of spirit, which needs no support other than its own overwhelming authority for the awakened mind. We all know the difference between being less awake and more awake, less responsive to the objective environment and more so. And we all trust our relatively more awake states more than our relatively somnolent states; for the very good reason that, the more comprehensively and accurately we are aware of the objective environment, the more our enterprises are likely to succeed. The kind of experience that I have called "spiritual" comes with an undeniable sense of "being very much awake," in the sense that it presents a vision or revelation of aspects of the objective reality that are *not* revealed in the self-absorbed kind of experience.

Incidentally, the more awake kinds of experience are also the more developed biologically and psychologically, and have had survival value in the long run. But in the sphere of spirit, survival value is not itself the test. The criterion must be simply the verdict of the most lucid consciousness itself, which emphatically declares the way of life called spiritual to be the highest good.

VII. A Commonwealth of Worlds

In the light of this all too superficial discussion of the spirit, I can now say what, in my view, is the right use of the planets.

If any of them is inhabited by intelligent beings, then clearly man should

do his utmost to adopt a relationship of genuine community with those non-human intelligences, seeking earnestly to enter into their point of view, and to co-operate with them for mutual enrichment, both economic and spiritual.

But since it is unlikely that any other planet is in fact inhabited by intelligent beings, then the question that we must answer is, what should man do with those virgin worlds? And the answer is that he should deal with them precisely as with his native world. He should use them neither for the sole purpose of increasing his luxury, nor simply as a means to power for mere power's sake. He should use them for the spirit. He should avail himself of their resources in such ways as to advance the expression of the spirit in the life of mankind. He should use them so as to afford to every human being the greatest possible opportunity for developing and expressing his distinctively human capacity as an instrument of the spirit, as a centre of sensitive and intelligent awareness of the objective universe, as a centre of love of all lovely things, and of creative action for the spirit. He should strive to make of the human race a glorious example of personality-in-community, a society of very diverse individuals united in mutual insight, understanding and sympathy, and in co-operative expression of the spirit. And for the full expression of the spirit in any community, the greater the diversity of individuals the better, provided that they all have sufficient imagination to enter into each other's points of view.

It is in this connection that the planets open up new possibilities. If man can establish in some of those other worlds new and specially adapted human or quasi-human races, then those races, living in their appropriate ways, should develop new expressions of the spirit at present inconceivable to terrestrial man. And through the intercourse of these diverse worlds, provided that each species has sufficient imaginative power, all should be spiritually enriched. Thus the goal for the solar system would seem to be that it should become an interplanetary community of very diverse worlds each inhabited by its appropriate race of intelligent beings, its characteristic "humanity," and each contributing to the common experience its characteristic view of the universe. Through the pooling of this wealth of experience, through this "commonwealth of worlds," new levels of mental and spiritual development should become possible, levels at present quite inconceivable to man.

A homely analogy may be hazarded. The really satisfactory marriage is not one in which husband and wife have identical character and interests, but one in which each is as different as possible from the other, though each has enough imagination to enter into the other and share the other's interests. In fact, the satisfactory marriage is a unity in diversity and a spiritual symbiosis.

Another analogy may help. Mankind to-day is deeply divided between two profoundly different systems of thought and value, two ideologies. Roughly, these ideologies centre upon America and Russia respectively. Each, I believe, contains very important truth which the other ignores. If war is avoided, and if in due season each side can learn from the other, the result may be a far more adult and spiritually enriched humanity than could ever have occurred without this cultural clash of mighty opposites. Incidentally, I cannot help hoping that Western Europe, and particularly Britain, may play

an important part in the unifying of the two half-truths. For Europe is in a position to sympathize with both the half-truths. Formerly champions of individual liberty, we are now being forced by dire circumstances to plan our own society and discipline our individualistic impulses. Perhaps we shall be able to give the world an object lesson in planning for liberty. Add to this the fact that after all, with due respect to those vigorous adolescents, the Americans and the Russians, Europe, with all its faults, is relatively adult; and moreover is the custodian of a great tradition of civilization and spiritual life which has still an important function in this largely barbarian world. America and Russia, yes, and India and China, have doubtless momentous parts to play in the future; but to-day it is the European temper, yes, and particularly the temper of this island people, that is needed to restore unity to a divided mankind, and save our species from destroying itself. It is a solemn thought that perhaps our actions here and now, in this island, in this great city, may determine whether that dream of a commonwealth of worlds is to be made real or made for ever impossible.

VIII. Man and the Cosmos

I shall now add a postscript on a larger theme. Thus far we have been considering only the solar system. What of the stars? What of the galaxies of stars? And the cosmos as a whole? Interstellar travel seems to us the wildest fantasy. However, we should not entirely rule out the possibility that a human race far more advanced than ourselves might some day travel far beyond the limits of the solar system. It might for instance be possible, through skilled use of atomic power, to propel a planet on an interstellar voyage. The substance of the planet itself would have to be used up for the initial propulsion of the planet beyond the range of solar gravitation, also for subsequent steering, also to provide its inhabitants with heat and light and food on the longest of all voyages. For the shortest of interstellar voyages would certainly take a very long time, in fact, thousands or millions of years. But if the task was considered worth while, it might perhaps be undertaken. And, who knows? It might conceivably be worth while to explore in this way some of the nearest planetary systems. But the method would obviously be extremely cumbersome. It is not quite inconceivable that a far better method may some day be developed. In view of recent spectacular but still very fragmentary discoveries in the field of paranormal psychology, it is just possible that communication with intelligent races in even the remotest planetary systems may be effected by a highly developed technique of telepathy. This, of course, is a surmise of the wildest sort; but to-day, when the very foundations of our knowledge are being transformed, it should not be ignored.

One thing we can say with confidence. *If*, by one means or another, man does succeed in communicating with intelligent races in remote worlds, then the right aim will be to enter into mutual understanding and appreciation with them, for mutual enrichment and the further expression of the spirit. One can imagine some sort of cosmical community of worlds.

Further, we may, I think, be certain that, wherever, in any age or any

galaxy, beings exist who are developed up to or beyond the level of awareness precariously attained by man at his best, there the imperious claim of the spirit, and therefore the ideal of personality-in-community, will surely be recognized. For this ideal and this claim are implied in the very nature of the awakened consciousness. It is nonsense to suppose that any humanly or superhumanly developed beings might permanently seek quite different values. The ideal of the spiritual life is involved in the very nature of personality. Apart from special cases of perversion or obsession by minor ends, the supreme end, which is the fulfilling of the spirit, cannot but be acceptable to the awakened consciousness. The ultimate goal of all awakened beings must inevitably be (how can one least misleadingly put it?) the expression of the objective cosmos in subjective experience and creative action, the fulfilment of the cosmos in cosmical awareness.

The more obvious way in which this goal is to be approached is through a cosmical community of worlds. But such a community may be nothing but the most fantastic of human dreams. Far more probably, the intelligent races within the cosmos may be for ever isolated from each other by the spatial immensities. In this case we are faced with two alternatives. We may suppose that God himself (or the supra-temporal mind of the cosmos) embraces in a single cosmical experience, all the worlds and all their age-long lives; or we may declare simply that the goal of cosmical awareness is not attained, and is only a crazy human fantasy. In this case we may suppose either that there is no general purpose at all behind the cosmos (which may very well be the case), or else that the purpose is something wholly unintelligible to human minds, and indifferent to the expression of the spirit in any world. Or we may suppose that it is equally false to say either that there is or that there is not a cosmical purpose, since the truth is utterly beyond our comprehension. The cabbages in a garden are grown not that they may fulfil themselves in flower and fruit but simply that, before reaching maturity, they may be eaten. Similarly, it may be that the intelligent worlds of the cosmos are required merely to reach a certain low stage of spiritual growth before being destroyed. Let us remember, too, that, if modern physics is correct, there awaits all worlds the cosmical night promised by the increase of entropy. Thus there is a race between cosmical fulfilment and cosmical death, between the complete awakening of consciousness in the cosmos, and eternal sleep.

But probably these wild speculations are all entirely beside the mark, because conceived in terms of ideas wholly inadequate to the actual conditions of the cosmos. For instance, our conception of time itself is now turning out to be very incoherent and superficial. Perhaps (who can say) from the point of view of eternity the end of the cosmos is also its source and its temporal beginning. Perhaps the ultimate flower is also the primal seed from which all sprang. Perhaps the final result of the cosmical process is the attainment of full cosmical consciousness, and yet (in some very queer way) what is attained in the end is also, from another point of view, the origin of all things. So to speak, God, who created all things in the beginning, is himself created by all things in the end.

Such fantasies may have some kind of symbolic truth, just as the Bible story has symbolic truth. Anyhow, whether true or false, they may at least help us to feel something of the mystery and immensity that surrounds our little human life.

To-day there are hints that the immensity may be far greater than is supposed even in modern astronomy. Paranormal investigations obscurely suggest that the whole spatio-temporal physical universe may be but one very limited and easily misinterpreted aspect of an underlying reality which transcends space and time and the whole seeming-solid world of common sense and science. This is not the place to open up so vast a subject; but I should like to make one comment. Even if in the end these uncertain hints are justified, we shall not have to suppose that therefore the familiar universe is unreal, or sheer illusion. Rather it will have to be regarded as real but not the whole truth; and as "false" merely if we take it to be the whole truth. Further, it seems clear that, whatever the immensities beyond our familiar sphere, for us, who are so deeply implicated in this sphere, the supreme concern must continue to be life here and now. What we have to do is to make the best of this planet of ours, and perhaps of other worlds also.

DISCUSSION

Mr. R. A. SMITH proposed a vote of thanks to the speaker, saying that he was particularly grateful for the philosophical support he had given to the interplanetary enterprise. It was hard, however, to feel any kinship or sympathy with some of the weird types of "man" that Dr. Stapledon had invented for the colonisation of very large planets. To this Dr. Stapledon replied that he could accept any life-form, however alien, if it was orientated to the fundamental values—which he considered must hold for all races at all times.

Mr. A. C. CLARKE then formally opened the discussion, commenting first on some technical points. He thought that life—though not intelligent life—might be more common and more varied in the Solar System than generally imagined. Even ignoring the four giant planets (which seemed to be partly gaseous) there were fourteen bodies of over a million square miles, and at least two hundred asteroids of over ten thousand square miles area. We had plenty of exploring to do!

Dr. Stapledon had touched on the possibility of telepathic contact with other races: but presumably as far as the Solar System was concerned, some sort of clairvoyance would be required, since there would be no intelligence to "transmit" at the other end. Mr. Clarke had often been given vivid descriptions of Mars by mediumistic characters, and he hoped that, before the first expedition, such reports could be collected as it would provide a unique opportunity for a convincing proof. However, the Technical Committee would be most annoyed if, after it had worked for years on atomic spaceships, the clairvoyants got to Mars first.

Dr. Stapledon, Mr. Clarke thought, had somewhat over-estimated the—admittedly enormous—difficulties of *interstellar flight*. If highly efficient atomic step-rockets could be developed, speeds of over 90 per cent. of the velocity of light were theoretically possible. The nearest stars could thus be reached in five or ten years—though the elapsed time to the crew might be much less than this, thanks to relativity effects.

Mr. Clarke did not think that Man could ever take part in a Galactic culture, even assuming that the technical difficulties involved could be overcome. The human mind would be strained to the utmost to deal with a solar civilisation of even a dozen worlds. A *galactic* society implied an increase in complexity of perhaps a thousand million. However, it was foolish to worry about these ultimate questions: what we had to do now was to make the best of our own planet, and of the other worlds when we reached them.

Many members of the large audience then took part in the discussion, and the following are some of the points raised.

One speaker suggested that before human beings colonised Venus, its climate and atmosphere might be modified by suitable plant forms projected from Earth, adding that perhaps terrestrial life came originally from Mars in a similar manner.

A chemist decried loose talk of destroying the human race by atomic energy: the *daily* increase in population equalled the casualties produced by the Nagasaki bomb. Fissile materials were so rare that it seemed most unlikely that they could ever be used to alter climates or geographical features.

Another speaker wanted to know what would happen if we met a race at about the same level of culture. Which would pickle which? It was suggested that there would be insuperable difficulties in communication if we encountered beings whose senses were entirely different from our. There might be a total lack of understanding like that depicted in Wells' *Country of the Blind*.

One member wanted to know if it might not be better to adapt *non-human* terrestrial life forms to colonise the planets, instead of trying to evolve new types of man.

A final speaker said that if we encountered inferior races, we must not put them in reservations, but must educate them. The selection of suitable colonists would also be a difficult psychological problem.

In reply, Dr. STAPLEDON said that though in this time of crisis we must put our own house in order, scientific endeavour must not be too utilitarian, but must always be opening up new frontiers. We must also preserve a sense of humility and piety towards the unknown: of late, humanity had been guilty of *hubris*—pride in achievement.

Dr. Stapledon did not agree that he had exaggerated the potentialities of atomic energy. Our present use of heavy elements was only a beginning—later we might release power from the lighter ones, as the stars do.

If we met a race that nearly matched us in culture, Dr. Stapledon hoped that co-operation would be possible, and that we would not treat it as we had treated the aborigines. On the other hand, if it was superior and turned Earth into a reservation, that would be the end of humanity, as it would lose the will to live. He agreed that we should try to educate other races—as long as we were sure we were educating them *up* and not *down* to our level.

He thought that races with *utterly* different senses were impossible. If they shared the physical universe with us, then they must have at least some senses in common with mankind, since they would have to perceive and manipulate matter. Even if they possessed senses outside our range (e.g. electrical, infra- or ultra-visual) we would still be able to comprehend them.

Dr. Stapledon did not think that it would be practicable to develop non-human life forms for interplanetary colonisation. It would be too great a task to bring them up to our level first. According to Huxley, no other existing species could develop human intelligence—they were all too specialised in other directions.

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THE ATOMIC ROCKET—2*

By L. R. Shepherd, B.Sc., A.Inst.P. and A. V. Cleaver, A.R.Ae.S.

4.—Choice of Propellant

In Part I, it was shown that, on present knowledge, by far the most promising line of development for applying nuclear energy to rocket propulsion would seem to be its use in a secondary manner, the nuclear "fuel" being used to supply heat energy to an inert working fluid, or "propellant." The "propellant," expanded as a gas through a more or less conventional nozzle, would constitute the main mass of the propulsive jet.

Broadly speaking, there are two possible ways in which such a reactor might be realised—the "solid" and "gaseous" systems discussed in greater detail in the next section—but the principal considerations governing propellant choice are common to both types and are mostly independent of problems specifically related to nuclear physics. Indeed, the basic principles involved are largely the same as those which influence the choice of propellants for combustion rockets, with the one important difference that dissociation is always advantageous to the atomic rocket, in contrast to its adverse effect on the performance of those operating on purely chemical reactions.

From considerations of momentum and adiabatic expansion, the following well-known equations, applying to any rocket motor, can be developed (see, e.g. reference 1, quoted in Part I):—

$$T = m_p.v_x + (P_x - P_e).A_x \quad \ldots\ldots\ldots\ldots\ldots\ldots (II.1)$$

$$v_x = \sqrt{\frac{2\gamma}{\gamma - 1} \cdot \frac{G\theta_o}{M} \cdot \left\{ 1 - \left(\frac{P_x}{P_o} \right)^{\frac{\gamma - 1}{\gamma}} \right\}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (II.2)$$

$$A_x = \frac{m_p}{P_o \sqrt{\frac{2\gamma}{\gamma - 1} \cdot \frac{M}{G\theta_o} \cdot \left(\frac{P_x}{P_o} \right)^{\frac{2}{\gamma}} \left\{ 1 - \left(\frac{P_x}{P_o} \right)^{\frac{\gamma - 1}{\gamma}} \right\}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (II.3)$$

where:—

T = Thrust (kg. or lb.).

m_p = Mass flow of exhaust gases, as in Part I (newtons/sec. or slugs/sec.: 1 newton = 9·81 kg. mass; 1 slug = 32·2 lb. mass).

v_x = Gas velocity at nozzle exit (metres/sec. or ft./sec.).

A_x = Nozzle exit area (m.² or ft.²).

P_x = Gas pressure at nozzle exit.

P_e = External pressure at nozzle exit.

P_o = Gas pressure in chamber, at start of expansion.

(All pressures in kg./m.² or lb./ft.².)

θ_o = Gas temperature in chamber, at start of expansion (°K. = °C. absolute).

*Part I was printed in the September *Journal*.

M = Mean molecular weight of gases. (N.B.—Not to be confused with use of same symbol in Part I.)

$\gamma = \frac{C_p}{C_v}$ = Specific heat ratio of gases.

(M and γ must be the average values obtaining over the whole expansion.)

G = Universal gas constant (kg.-m./newton mol or ft.-lb./slug mol, per °K.).

At great altitudes, P_x approaches zero, and it is convenient also to adopt the concept of an "effective exhaust velocity" (v_e) such that for $P_x = 0$ we have:—

$$v_e = v_x + \frac{P_x \cdot A_x}{m_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (II.4)$$

and:—

$$T = m_p . v_e \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (II.5)$$

On this basis, manipulation of equations (II.2), (II.3) and (II.4) gives the results:—

$$v_e = K \times F \times \sqrt{\frac{\theta_o}{M}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (II.6)$$

where K is a constant (= 0·129 for v_e in km./sec.), and F is a factor given by:—

$$F = \left\{ \sqrt{\frac{\gamma}{\gamma - 1}} \cdot \left\{ 1 - \left(\frac{P_x}{P_o} \right)^{\frac{\gamma - 1}{\gamma}} \right\} \right. + \frac{\left(\frac{P_x}{P_o} \right)^{\frac{\gamma - 1}{\gamma}}}{2 \sqrt{\frac{\gamma}{\gamma - 1}} \cdot \left\{ 1 - \left(\frac{P_x}{P_o} \right)^{\frac{\gamma - 1}{\gamma}} \right\}} \quad \ldots\ldots (II.7)$$

These last two equations indicate the thermodynamic characteristics of an ideal propellant gas.

In Fig. 1, curves are plotted showing the numerical results from (II.7) in terms of γ and P_o/P_x. The latter parameter, called the "expansion ratio," is under the control of the designer, but two factors limit his natural desire to use the highest possible value, which the curves show is advantageous. These factors are:

(*a*) Very high values of P_o lead to excessively heavy chambers, due to the high stresses associated with such high pressures, and

(*b*) very low values of P_x imply the need for nozzle exit areas of inconvenient size (an infinite area would be required for the ideal case of $P_x = P_e = 0$) and, once again, of excessive weight.

Current practice on chemical rockets is to design the nozzle for an expansion ratio not exceeding 25. ($P_o = 25$ atmospheres and $P_x = 1$ atm., approx.—the latter being desirable to avoid over-expansion for some cases of operation

FIG 1. VARIATION OF FACTOR F WITH γ AND EXPANSION RATIO P_0/P_x ~

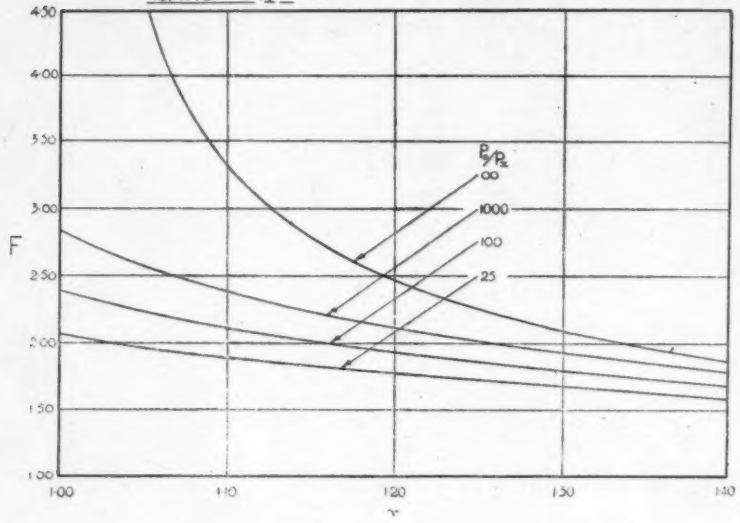
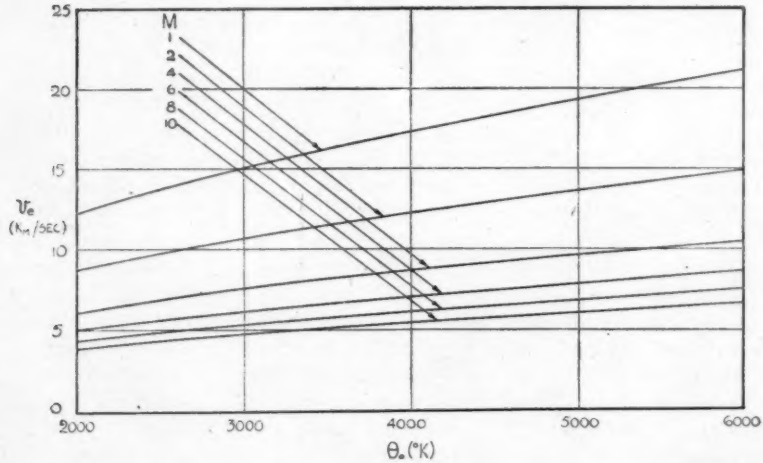


FIG 2. VARIATION OF EFFECTIVE EXHAUST VELOCITY (v_e) WITH CHAMBER TEMPERATURE (θ_0) AND MOLECULAR WT (M). EXPANSION RATIO = 100 & γ = 1·10, HENCE F = 2·11. ~



within the atmosphere.) For a spaceship motor, a ratio of about *100* might be expected, corresponding to increased P_o and decreased P_e.

It must be remembered that Fig. 1 shows the variation in performance with the two parameters concerned *for a given value* of the initial gas temperature. Hence, an available improvement is indicated from decreasing γ to some low value (approaching the unity of isothermal expansion), especially for large expansion ratios. The quantity γ is, of course, primarily a characteristic of the propellant gas chosen, but an *effective* γ approaching unity could be obtained by feeding in heat energy continuously during the expansion, instead of in one initial stage in the chamber. The chamber and nozzle would then, in effect, be combined in one elongated space. Such a scheme might at first sight appear to have great advantages, since a given high exhaust velocity could be obtained for a lower chamber temperature, and the structural problems associated with high temperatures are well known to be the main difficulty in any rocket motor design. In fact, however, the position is not quite so simple as such superficial considerations might make it appear.

The worst cooling conditions in a rocket motor occur, not in the chamber where the temperature is a maximum, but near the nozzle throat, where the temperature is still high but the gases have also accelerated to high velocity. The latter condition results in the heat-insulating boundary layer of gas being scrubbed way, with consequently increased conductance of heat to the walls. Thus, a "near-isothermal" motor might have a much lower chamber temperature for a given exhaust velocity, and yet still give worse combinations of temperature and velocity where the cooling conditions were more critical, since its exhaust temperatures, of course, would be higher throughout the nozzle. This argument pre-supposes that the principal mechanism of heat transfer is by conductance, as it is for present rocket motors; this condition may not always remain true, hence the case for a deliberate attempt to achieve a low effective γ may sometimes remain.

If motors are ever operated at temperatures so high that most heat transfer to their walls is by radiation, then the argument for "near-isothermal" expansion is good. Another factor tending the same way, especially for the nuclear motor, would be the realisation that the sheer melting point of some component part was limiting the acceptable temperature at some station along the chamber-nozzle assembly—for example, the particular materials of the pile supplying heat to the gases in a "solid" reactor, rather than of the chamber walls themselves. The required energy input of a "near-isothermal" motor would of course be higher (lower thermal efficiency) for a given exhaust velocity, but this would not be of prime importance for an atomic motor.

However, it will be shown later that the γ values applying for any atomic rocket motor will be much lower than might be expected from experience with normal gas expansion cycles, even without any special design provisions. A value not exceeding *1·1* is likely to be typical, and using this in conjunction with the expansion ratio of *100* previously suggested, Fig. 2 has been prepared from (II.6). In practice, the exhaust velocities shown in Fig. 2 would be reduced by the losses due to friction and shock in the nozzle. For chemical motors of the present day, such reduction is of the order of 5 per cent., but the

effect has been neglected for this preliminary analysis. The trend of v_e with θ_o and M shown here at once reveals the most important propellant requirement of all:—

(*a*) The value of θ_o should obviously be as high as can be accepted from considerations of cooling and strength. This done, *the propellant molecular weight should be a minimum.*

Note that the effect of dissociation phenomena, for a given energy input to the gas complex, is always to reduce both θ_o and M. Thus, in a chemical rocket motor using propellants of given calorific value, a loss in performance results because the lower θ_o is only partly compensated by the lower M; the overall effect is to make dissociation less serious as a source of loss than it would otherwise be, but—assuming the motor could have withstood the higher θ_o which would have obtained without dissociation—it is nevertheless disadvantageous, because some of the available useful energy has disappeared. An atomic motor would be an entirely opposite case; for it, the designer would almost certainly have available all the energy he required and would aim for a given working *temperature* (θ_o). If, to maintain this temperature, extra energy had to be supplied because of dissociation, then it would be forthcoming from the abundant stores available. Dissociation would become a friend rather than an enemy because it would reduce the value of M applying at the chosen working temperature, which would be decided purely on a structural basis.

We have already seen that it may also be an advantage to have a low γ for our propellant, and still further requirements can be deduced from common-sense consideration of the practical factors involved. These, while subordinate to the fundamental requirement (*a*), are still very important, and are analogous to the similar ones applying in the choice of chemical propellants:—

(*b*) The specific gravity in liquid form should be as high as possible, to reduce tankage volumes and hence hull size, weight and air resistance (though the latter feature will be of negligible importance, the others decidedly would not).

(*c*) The storage and handling characteristics of the liquid should be reasonable. Primarily this implies as high a boiling point as possible, but considerations of toxicity, explosion risk, cost, etc., would also affect the issue once it entered the realm of practical politics. The properties of the liquid as a regenerative chamber coolant would also be important.

A great many substances would have to be considered in detail before any final choice could be made. Table III lists a few of the numerous possibilities, chosen with consideration (*a*) mainly in view, but with (*b*) and (*c*) in mind as important qualifications. As might be expected, no single fluid is ideal on all counts; hydrogen, which is quite easily the best on the fundamental issue, is about the worst on all the others.

TABLE III

Fluid	Chemical Formula	*Molecular Weight (M)	Specific Gravity	Boiling Point (°C.)
Hydrogen	H_2	2·02	0·07	— 253°
Deuterium (= Heavy hydrogen isotope)	D_2	4·04	0·17	— 240°
Helium	He	4·00	0·29	— 269°
Water	H_2O	18·02	1·00	+ 100°
Heavy water	D_2O	20·04	1·10	+ 101°
Ammonia	NH_3	17·03	0·68	— 33°
Heavy ammonia	ND_3	20·05	0·71	— 31°
Methane	CH_4	16·03	0·42	— 161°

Deuterium and some of its compounds have been included because of the one respect in which considerations of nuclear physics have a very important bearing on propellant choice. These are particularly important for the "gaseous reactor,"† and will later be elaborated; for the present, it will suffice to point out that hydrogen and its compounds have a pronounced tendency to capture neutrons, whereas deuterium has not. Thus, for use in cases where it is important not to subtract from the available number of neutrons, there may be some advantage in substituting deuterium atoms for the hydrogen ones; all hydrogen compounds can exist in such forms. Of course, deuterium is a relatively rare and expensive isotope to produce, but such a proposal, even on a large scale, is probably not beyond the bounds of future practicability; a very slight increase in density is some small additional compensation.

As noted on Table III, the molecular weights quoted there do not allow for dissociation effects at high temperature, and hence are only of interest as very rough indications. Dissociation is particularly important in the case of some of the compounds with more complex molecular structures, and which may conceivably become of great practical interest because of their greater density and ease of handling. Ammonia, for example, undergoes an almost complete reaction—

$$2NH_3 \rightarrow N_2 + 3H_2 - 0{\cdot}93 \times 10^3 \text{ kilocals./kg.}$$

even at temperatures as low as 1,000° K., even at considerable pressures. This makes the molecular weight of its products 8·52 instead of 17·03, and at higher temperatures, still further reductions follow as a percentage of the nitrogen and hydrogen becomes monatomic.

* Neglecting dissociation.

† *i.e.* a system in which the fissile fuel is made to react in the gaseous, instead of the solid, phase. See forthcoming Part III.

Using the data of reference 2, some calculations have been made for the cases of hydrogen and ammonia as working fluids. Allowance has been made, where appropriate, for the dissociation reactions:

$$H_2 \rightarrow 2H - 51{\cdot}3 \times 10^3 \text{ kilocals./kg.}$$
$$\text{and } N_2 \rightarrow 2N - 6{\cdot}05 \times 10^3 \text{ kilocals./kg.}$$

in addition to the low temperature dissociation of ammonia already noted. The molecular weight values arrived at should be compared with those of Table III; they are the average values obtaining over an expansion from the maximum initial temperatures (θ_o) specified, on the arbitrary but reasonable assumption that the initial pressure (P_o) would be 50 atmospheres and the nozzle exit pressure (P_x) 0·5 atm. The results are presented in Table IV.

TABLE IV

E_1 = Energy absorbed per kg. of propellants in sensible heat.
E_2 = Energy absorbed per kg. of propellants in dissociation reactions.
(In each case, expressed in kilocals. $\times 10^{-3}$, and representing the heat absorption to attain the quoted θ_o values.)
$E = E_1 + E_2$.

	Chamber Temperature, θ_o											
	3,000° K.				4,000° K.				5,000° K.			
Propellant	M	E_1	E_2	E	M	E_1	E_2	E	M	E_1	E_2	E
H_2	2·0	10·7	0·6	11·3	1·9	15·2	6·0	21·2	1·7	19·7	22·0	41·7
NH_3	8·5	2·6	1·0	3·6	8·1	3·6	2·2	5·8	7·3	4·7	9·8	14·5

The enthalpy values included in the tabulation allow, of course, for the increase in gas specific heat with temperature. On this basis, the value of the expansion index γ would be approximately 1·35. The effects of re-combination of dissociated molecules, as the pressure and temperature drop along the nozzle, must also be allowed for, and the hypothetical atomic motor which is under review introduces still further considerations. Gases leaving the reaction chamber will continue to be violently radio-active throughout the expansion, and hence the gas complex will be strongly ionised and will continue to receive energy right up to the nozzle exit (and beyond—but that will contribute no useful effect). In the case of the "gaseous reactor," such influences would be particularly marked, since many fissile atoms would not disintegrate and release their energy until they reached some point far along the nozzle. All these effects peculiar to the nuclear motor are extremely difficult to allow for on present knowledge, and in any case would be largely dependent on the final layout. However, prolonged consideration and rough calculations are believed to justify the value of $\gamma = 1{\cdot}1$ used earlier for Fig. 2. In practice, it is suspected that the index would be even lower (sometimes, it might even be $< 1{\cdot}0$). Yet another consequence would be a further reduction in the average molecular weight.

The increasing influence of dissociation phenomena at higher temperatures is apparent from Table IV; at 5,000° K., the energy absorbed in this way is

the greater part of the total. If operation were practicable at still higher temperatures, dissociation would become so complete that the hydrogen compounds (such as ammonia or water) would be almost as good as hydrogen on a molecular weight basis, and of course are always greatly preferable on the counts of storage and handling. They would eventually surpass helium (which is always monatomic) and, indeed, it seems unlikely that this element would ever be considered the most suitable propellant.

Summarising this section, it can be said that by employing hydrogen or one of its compounds, in either normal or isotopic forms, effective molecular weights of 1·5 to 8 seem practicable, and reference back to Fig. 2 shows that this would imply the possibility of exhaust velocities of 5 to 15 km./sec. at working temperatures of about 3,000° to 5,000° K. It remains to be seen what can be said of the constructional prospects of nuclear rocket motors at the present very early stage in their conception.

(*To be continued.*)

REFERENCE

(2) "Spezifische Wärme, Enthalpie, Entropie und Dissoziation technischer Gase," by Dr. E. Justi. Pub. 1938, by Julius Springer, Berlin; reprinted 1944 (in German), by Edwards Bros., Mich, U.S.A.

NOTES AND NEWS

Journal Binding

The Council has now arranged for special "Cordex" self-binding cases to be made available to members who wish to have their copies of the *Journal* bound. These excellent cases have been made specially for members, and are sufficient to hold the publications for a complete year, *i.e.* six *Journals*, one Annual Report and List of Members, and the Annual Index.

As *Journals* are received, they may be inserted in the patent case at once merely by slipping under the appropriate cord.

The cases are strongly bound in blue cloth, titled on spine, and are available at 5s. each, plus 6d. postage. They are undoubtedly of excellent value, and it has been found possible to make them available at a much reduced price owing to an order in quantity.

If any members would like to have further special cases made for Vol. 6, to contain seven *Journals*, 4 *Bulletins*, Annual Report for 1947 and Index, these can also be ordered for 7s. 6d. each.

Enquiries and remittances should be addressed to the Secretary.

Professor Oberth

We recently received, on loan from Willy Ley, a copy of a most interesting document entitled "The Design of a Long-Range Rocket," by Prof. Herman Oberth. Bearing the reference PB–22295, it was distributed in photostat form by the Office of the Publication Board, U.S. Dept. of Commerce, Washington 25, D.C., with the statement that all security restrictions on its contents had

now been lifted. (Subsequently, we have heard that the Detroit Rocket Society is going to re-print it, at a cost of $1.)

This report by the famous pioneer of astronautics was made at the close of the war to interrogators of the U.S.A.A.F., and was written entirely from memory, without reference to any technical material, this being an apparent consequence of Oberth's circumstances at the time. Partly for this reason it is of historical rather than technical interest, but even so, is a most valuable reference.

The activities at Peenemünde are described somewhat sketchily, but with many references to the organisation and personalities there which rouse one's curiosity; tentatively, one receives the impression that Oberth was retained by the official German rocket research and development authorities in a more or less advisory capacity. He seems to have been kept rather in the background, in a fairly subordinate position, rather than to have been given any very active part to play in the more practical work of the establishment. These impressions, of course, *are* purely tentative, and we stand open to correction by any better-informed source, but at least they are consistent with the fact that one has rarely seen Oberth's name mentioned in authoritative accounts of the work at Peenemünde. Perhaps his undoubted genius lay in the fields of brilliant long-term anticipation and fundamental theory, rather than in the more mundane realm of practical engineering development.

The title of the report refers specifically to a design project carried out by Oberth, in the latter part of 1941, for a trans-Atlantic missile. This seems to have been a competitive alternative to the A9-A10 combination, which, Oberth implies, shared the same fate as his own project, namely, to be considered impracticable at the time. Oberth even appears to have concurred in this view, but gives broad details (with sketches) of his design. Leading data are: Take-off weight = 90 tons, thrust = 180 tons, number of steps = 3, range = 6,000 km., propellants = oxygen and alcohol. The missile was to have been a pure rocket, *i.e.* no wings were fitted (as were to have been on A9).

It will no doubt interest B.I.S. members to learn that we understand Prof. Oberth is now engaged in farming; he is apparently quite well, is still very interested in interplanetary matters, and lives near Nuremberg.

A Plan for World Government

With this issue of the *Journal* we are including introductory literature issued by the *Crusade for World Government.*

The B.I.S. itself is not generally concerned with matters of everyday politics, but the Council feel that no apology is needed to make an exception in this case. World Government, indeed, is eminently desirable from the viewpoint of interplanetary travel, not only because it would make available resources which few countries can at present afford, but also because it would destroy the many dangerous ideologies which exist to-day.

The *Crusade for World Government* is an all-party organisation and is supported by many M.P.'s and a number of leading scientists and philosophers, including Olaf Stapledon, Sir John Boyd Orr, and Professor C. E. M. Joad, among others.

"For the last time, Benson, will you kindly refrain from muttering to yourself, 'Whither mankind, whither'!"

(*Reproduced by courtesy of the Editor of "Everybody's."*)

U.S. Guided Missile Expansion

The U.S. Navy is to construct a 7,500-acre laboratory to test radio-controlled missiles at Port Mugu, California. This new base (at a cost of $30 million) is to replace the temporary guided missile test centre operated at Port Mugu since October, 1946.

The laboratory is due for completion in 1951, and will include all the usual test machines, radio and radar devices, aircraft landing strip and military base facilities (*N.O.T.S. Rocketeer*, August 25th, 1948).

The Rings of Saturn

The problem of the tidal forces acting upon a fluid satellite was examined as early as 1850 by Roche, his analysis leading to the formulation of the well-known "Roche's Limit," this being the radial distance from the primary's centre inside which the satellite would be disrupted. The analogous problem of a solid satellite does not appear to have been considered, until a recent paper by Jeffreys.[1] He examines the deformation by a gravitational field of a solid, incompressible spherical body, stating that the compressibility of a real solid satellite would affect his results by only a few per cent. The general conclusion of his analysis is that a solid satellite, or small body making a casual close approach to the primary body, would not be disrupted by tidal action however close to the planets' surface, provided that its radius was less than a certain critical value, this value depending upon the density of the primary and the physical properties of the material of the small body.

He examines various special cases. For a rocky substance, the critical radius is 220 km., and for Jupiter about 450 km. This means that the asteroids could not have been formed by the tidal disruption by Jupiter of a single body (the usual explanation) for no number of approaches could have broken the body up into pieces of diameter less than about 900 km. For the similar case of Saturn's rings, Jeffreys follows the suggestion[2] that the high surface brightness of the rings is explainable as due to ice crystals; he examines the approach to Saturn of a sphere of ice, and shows that here again the conventional explanation of the rings as due to tidal disruption of a Saturnian satellite is untenable. For rocky material, the situation would be even worse.

Jeffreys emphasises that his investigation is supplementary to that of Roche. It would be possible for the present criterion to be satisfied outside the Roche limit. However, he also emphasises that unless this criterion is obeyed tidal disruption will not occur for a solid body even inside the Roche limit.

REFERENCES

(1) *M.N.R.A.S.*, **107**, 260, 1947 (published July, 1948).
(2) *J.B.A.A.*, **30**, 249, 1920.

THE BRITISH ASTRONOMICAL ASSOCIATION

Founded 1890, now numbers 2,000 members. Open to all interested in Astronomy. Chief objects are the association of observers for mutual help, circulation of astronomical information, and encouragement of popular interest in Astronomy. The Association issues a *Journal* about nine times annually, *Circulars* giving current Astronomical news, and *Memoirs* on the work of Sections, including the Sun, Planets, Comets, Auroræ, and Variable Star Sections.

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The Assistant Secretary, 303, Bath Road, Hounslow West, Middlesex.

KNOW YOUR COUNCIL

A. V. CLEAVER, A.R.Ae.S. Born 1917, educated at Acton Technical College and by evening studies at Northampton Polytechnic. After two years' general engineering experience joined what was then the Airscrew Division of the de Havilland Aircraft Co. in 1936, working in the drawing, stress and aerodynamics offices, and the development department. By 1946 was Chief Project Engineer of the de Havilland Propeller Co., and then transferred to the Engine Co. of the same group, with whom he is now Special Projects Engineer.

Mr. Cleaver has published a number of papers on airscrew and rocket propulsion, as well as a number of lectures to the B.I.S. He is now a Council member of the Royal Aeronautical Society and a member of the Rockets Sub-Committee of the Aeronautical Research Council. Joined the Society in 1937, but held no pre-war office in the Society. He kept in touch with other active B.I.S. members during the war, joined the C.B.A.S., and was among the small group of enthusiasts who were responsible for the re-birth of the B.I.S. in 1945 and the amalgamation of all British astronautical interests at that time. He held the office of Chairman of the B.I.S. Council for the session 1947-48, and has been a member of our Council for the whole post-war period.

Mr. Cleaver tells us that his interest in interplanetary flight dates back as long as he can remember—certainly until some twenty years ago, when he submitted (unsuccessfully) an article on the subject to *Meccano Magazine*!—and says it arises from two causes. The first of these concerns the fascinating possibilities of the achievement itself, the second the absorbing interest of the technical problems involved. He believes the solution of the latter will be exceedingly difficult, but thinks success will come "before the turn of this present century."

L. J. CARTER, F.R.S.A., A.C.I.S., A.B.I. Born 1922, and educated at the Paragon School, S.E. London. Has worked on the business side of many undertakings, including retail and finance firms, tailoring, motor and electrical engineering, and others. Was engaged on the organisation and administration of NAAFI, and later became Assistant Secretary to a professional association of Secretaries and Accountants. Has been a lecturer on accountancy and allied subjects at part-time classes for the last three years, his students obtaining 100 per cent. passes, and one of them winning the Silver Medal of the Royal Society of Arts.

Mr. Carter has been interested in scientific matters and, in particular, has been an amateur astronomer for a number of years. Before the war he was one of the few astronomers who found any sympathy for interplanetary travel in their hearts, his interest in space flight beginning with an early realisation that telescopic observations alone could not possibly solve all the mysteries of planetary conditions. The only practicable answer, he felt, was to go and look around on the spot!

He joined the B.I.S. in 1937 and served on the Members' Committee in 1938. Rejoining the Society in 1945, he acted in an advisory capacity to both the B.I.S. and G.B.A.S. on administrative affairs, finally undertaking the incorporation of the new post-war Society and its Secretaryship. He is responsible for the production of the *Journal*, in association with the Publications Committee,* and (as Secretary) for most of the work involved in running the Society—correspondence, accounts and finance, arrangement of meetings, etc.

* Of which the present members are Messrs. Clarke, Shepherd and Cleaver.

ABSTRACTS

Edited by J. HUMPHRIES

Properties of Gases

(F. G. Keyes *et al.* *Trans. A.S.M.E.*, August, 1948, Vol. 70, No. 6, pp. 621–66, tabs., illus., bibl.)

A series of 10 articles reviewing the available thermodynamic and physical properties of He, A, Hg, H_2, N_2, O_2, CO, H_2O, CO_2, NH_3, CH_4 and C_2H_4. The survey was made for the A.S.M.E. Research Committee on Properties of Gases with a view to initiating work to cover the gaps in present knowledge. Comprehensive bibliographies are included on p–v–T data, dynamic viscosity and thermal conductivity, amongst other things. The reviews of the available data indicate a critical need for additional experimental work, especially at temperatures above a few hundred degrees Centrigrade.

Generalised Thermodynamics of High-Temperature Combustion

(H. C. Hottel, G. C. Williams and C. N. Satterfield. *Trans. A.S.M.E.*, August, 1948, Vol. 70, No. 6, pp. 667–76, graphs, tabs., bibl.)

This paper presents a method of expressing the thermodynamic properties of the four-component system, C–H–O–N, in a dimensionless form which permits putting the whole system on to a simple set of charts for easy engineering use. The present data have particular value in calculating flame temperatures and in solving the performance of liquid-fuel rocket power plants. The method of use is illustrated by application to a rocket system.

The Density of Aqueous Hydrogen Peroxide Solutions

(C. E. Huckaba and F. G. Keyes. *J. Am. Chem. Soc.*, July, 1948, Vol. 70, No. 7, pp. 2578–83, tabs., refs.)

The densities of aqueous solutions of hydrogen peroxide at 0° C. have been determined with a precision of 1 part in 5,000. The coefficients of change with temperature in these densities have been determined from 0° to 20° C. with a precision such that densities calculated using the coefficients also have a precision of 1 part in 5,000.

Some Considerations of the Effect of Radiation on the Performance of Liquid Fuel Rockets

(S. S. Penner and S. Weinbaum. *J. Opt. Soc. Am.*, July, 1948, Vol. 38, No. 7, pp. 599–603, illus., refs.)

Equations have been developed for estimating the temperature rise, caused by the absorption of radiant energy, of a small volume element of cool gas or of a liquid droplet moving along the axis of a cylindrical chamber. The absorbing material was assumed to move with constant velocity and to be surrounded at all times by hot radiating gases distributed uniformly throughout the cylindrical chamber. A sample calculation has been carried out for an absorbing volume element of gas moving with a linear velocity of $1{\cdot}15 \times 10^4$

cm./sec. through a cylindrical chamber (30 cm. in length and 14 cm. in diameter) filled uniformly with grey body emitters at 3,000° K. and 20 atm. pressure. The mass emissivity of the radiating gases was chosen to be 40 sq. cm./g. The upper limit for the temperature rise of the moving gases, caused by the absorption of radiant energy, was found to be about 100° K. for the chosen conditions.

Impulse Determinations of Rockets by Means of Rotating Systems

(S. S. Penner and R. C. Whiteman. *Rev. of Sci. Insts.*, July, 1948, Vol. 19, No. 7, pp. 428–35, illus., graphs, tabs., refs.)

Two simple rotating systems have been designed for the determination of the specific impulse of rocket propellants. The pin wheel consists of a bicycle wheel mounted horizontally in a steel frame. A small rocket motor containing the propellant which is to be tested is mounted on the wheel so that the thrust delivered by the rocket accelerates the wheel. A photographic record of the rotational speed is then used to calculate the impulse delivered as a function of time. The rotating bar is operated in a similar manner.

The rotating systems have been used for the determination of relative effective gas velocities of a number of double-base rocket powders. Impulse measurements of miniature rockets of the order of 1 pound-second were made. An investigation of the effect of expansion ratio of rocket nozzles on the reduced specific impulse showed good agreement with theoretical calculations.

Equations of Motion of a Rocket

(F. R. Gantmacher and L. M. Levin. *Appl. Math. Mech.* [Akad. Nauk. S.S.S.R. Prikl. Mat. Mech.], 1947, Vol. 11, pp. 301–12. (In Russian, English summary.)

The equations as first obtained depend upon (*a*) external forces due mainly to the pressure of the air, (*b*) forces due to the reaction caused by the ejected gases, and (*c*) coriolis forces. The latter two groups are investigated in greater detail and are expressed in terms of the rate of ejection of the gases from the burning charge surface and from the nozzle, the variation in density, the angular velocity and other parameters. (From rev. in *Math. Revs.*, March, 1948, Vol. 9, No. 3, p. 162.)

The Powder Metallurgy of Porous Metals and Alloys Having a Controlled Porosity

(P. Duwez and H. E. Martens. *Metals Technology*, April, 1948, Vol. 15, No. 3, Tech. Pub. No. 2343, 27 pp., illus., graphs, tabs., refs.)

One of the methods of reducing the chamber and nozzle wall temperatures in a rocket motor is by "sweat-cooling." This method of cooling consists of making the part to be cooled of a porous material, so that the cooling fluid can be forced through the pores. The temperature of the coolant moving in a direction opposite to that of the heat flow increases gradually while passing through the porous material, and the coolant forms a protective layer on the surface exposed to heat. Generally, the proper pressure drop and rate of flow of coolant are deduced from heat transfer and design considerations,

and consequently the permeability of the porous metal to be used is also determined.

A method has been developed by means of which porous metals and alloys having a controlled permeability can be prepared. The method consists essentially of mixing a porosity-producing substance with a metal powder, pressing the mixture and sintering at a suitable temperature. During heating, but before sintering takes place, the porosity-producing substance dissociates, thus creating the desired porosity.

Atomic Power for Aircraft

(A. Kalitinsky. *Aero Digest*, August, 1948, Vol. 57, No. 2, pp. 58–9, 121–3, illus.)

A brief review of the possible methods of application of atomic energy to turbojets, ramjets and rockets. The rocket because of its high performance and suitability for high speeds seems most promising. Aircraft will have to be large to accommodate such power plants and the problem of shielding will be an exceedingly difficult one.

Journal of the American Rocket Society,

(June, 1948, No. 74.)

The main items in this issue are "Robert H. Goddard—Father of Modern Rocketry," "The Pioneer Rocket Project of the U.S. Navy" and "Isothermal Expansion in Nozzles." Another short article entitled "Rockets on Rails" records that speeds of over 1,000 m.p.h. have been achieved with a rocket-propelled carriage running on a track. The immediate objective of the experiments was to obtain supersonic data.

Ceramic Materials as Liners for Combustion Chambers of Rocket Motors

(J. A. Slyh *et al.* Two reports published by U.S. Dept. Comm., Off. Tech. Serv. at $1.00 each)

PBL 79491, November, 1946, 9 pp., bibl.
PBL 79497, February, 1947, 11 pp.

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REVIEWS

Flights into the Future

(By Harry Harper, A. M. Low and others. Published in The Triumph Library by The Thames Publishing Co., 110, Fleet Street, E.C.2. 125 pp. 7s. 6d.)

B.I.S. members in search of a gift for youthful relatives or friends might do much worse than settle for this well-produced boys' book; in doing so, they would be striking a blow for the education of the Young Idea and perhaps ensuring a stream of future members. With only one exception, the *Flights into the Future* are all flights into space, and the old pre-war B.I.S. ship figures prominently, especially on the quite impressive cover-drawing. (The only drawback of which is that it belies the text and suggests that a bright blue sky is visible from the Moon.)

It is perhaps unfair to demand vigorous technical accuracy from such a work, but in point of fact the errors and mis-statements are far fewer than one might expect. We were flattered by the plausible facsimile of a future newspaper clipping on p. 7; it states: "Moonraker IV, the atom-powered space-flying rocket designed and built by members of the British Interplanetary Society at a cost of £8 million, left from a secret launching base on the evening of July 6, —"

Now, if we only had £8 million ! A. V. C.

Astronomie

(By Lucien Rudaux and G. de Vaucouleurs. Librarie Larousse, Paris, 1948. Pp. viii + 486; 866 illustrations, 12 colour plates.)

This is at once the most beautifully produced and up-to-date book on general astronomy with which we are acquainted. Its chief author, the late Lucien Rudaux, was well-known for his fine astronomical paintings, and the book's splendid illustrations are therefore not surprising—particularly outstanding being the colour plates of Mars, Jupiter and Saturn. The photographic plates are also very fine and include many recent and unfamiliar ones, of which perhaps the most striking are some of the Moon taken at the Pic de Midi Observatory, under magnifications considerably greater than those used in the famous Mt. Wilson photos.

The work is divided into four sections, the first of which gives a very clear description of the various phenomena of the night sky and their causes. The second and largest section is devoted to the sun and the solar system: how up-to-date this is may be judged from the fact that it contains a V.2 photograph of the Earth and a photograph of a radar screen showing meteor trails.

The third section deals with the stars and nebulae, the treatment being very comprehensive yet largely non-technical. (In this respect the book is a model of popular exposition.) One of the most striking illustrations is a "radio-frequency" map of the Milky Way, showing how exactly the intensity of "cosmic static" follows the contours of the great star clouds. It is a strange thought that even if the skies were invisible we could have discovered the structure of the Galaxy.

This section also contains one of the first accounts we have seen of the interesting theory of the formation of the Solar System developed by von Weizsäcker—while working on the German atomic energy project!

The book ends with a short but fascinating chapter on astronomical methods and instruments, which leaves one in no doubt that astronomy is now entering upon a great new period of expansion. Looking back on the last half-century, much of our present knowledge of the universe seems due directly to the Mt. Wilson 100-inch reflector: yet there are now under construction no less than five telescopes of equal or greater size. In addition the wonderful Schmidt telescope has made it possible to carry out astronomical surveys on a scale which would otherwise be quite out of the question.

No less significant are the many electronic devices now being adapted for astronomical research. To quote two examples from *Astronomie*, the "electron telescope" has been used to make visible stars which could not otherwise be detected, and Lovell's discovery of daylight meteor showers by radar is undoubtedly a milestone in the science.

Through this posthumous work M. Rudaux will pass on to many the sense of wonder and beauty which can be evoked by astronomy as by no other science. This feeling has been well summed up in a saying by the great physicist, Jean Perrin, which heads the last chapter of the book:—

> "C'est une bien faible lumière qui nous vient du Ciel étoilé. Que serait, pourtant, la pensée humaine si nous ne pouvions pas percevoir ces Etoiles. . . .?"

A. C. C.

Rockets and Jets

(By H. S. Zim. Published by Harcourt, Brace & Co., New York. 326 pp. 15s. in this country (from H. K. Lewis).)

This is yet another popular work on rocketry but quite good of its sort. Dr. Zim has a gift for explaining technical principles in simple language without, as a rule, sacrificing much of technical accuracy. One suspects that his book was directed mainly at the heads of the younger generation; although the adult lay reader will find it of interest, its appeal will be greatest to the more technically minded "teen-agers," as they would be called in the book's country of origin.

The history of rockets is once again outlined and much attention is devoted to the rocket weapons of World War II. The author also deals with aircraft jet propulsion, but draws a commendably clear distinction between it and true rocket propulsion. One is grateful for the statement, on p. 255, that: "The story behind the new jet-propelled plane is one that has all the earmarks of an American success story. However, it is a British tale and even its broader aspects are all European." Incidentally, the turbojet engine is credited with thermal efficiencies and jet velocities far beyond the true values.

The bulk of the volume, however, is devoted to rocketry. Errors are introduced in passing references to dissociation effects, monopropellants, and the relative merits of oxidisers other than liquid oxygen, and too much prominence

is given to the superficial theories of early A.R.S. experimenters on the virtues of nozzle-less motors and combustion outside the actual chamber. There is less excuse for an apparent confusion between the true nature of "escape velocity" and the existence of a gravitational "null-point" between Earth and Moon, also between the impression of weightlessness which would be experienced by a space-ship crew and the decreasing pull of gravity with increasing distance from Earth.

Most of these shortcomings, together with certain quantitative errors in specifying, *e.g.* V.2 performance, are understandable when one notes that the book was written in 1945, before the release of all the mass of relevant official information which has since become available. This also leads to some references to atomic energy which read rather quaintly today; after discussing the fission reaction of U235, the author states: "How soon this atomic energy will be made available nobody knows." A striking example of the speed of modern scientific development, and also of the secrecy with which it is conducted! (The date of the book is, incidentally, also responsible for the impression being given that the B.I.S. is no longer active but will renew operations "as soon as conditions permit.") A new edition of Dr. Zim's book would presumably be very drastically re-written, but it is a little surprising that it was issued (in 1946), and is still being sold over here, without some appendix or new introduction explaining the circumstances.

For interplanetary flight the author displays a modified interest and enthusiasm, well tempered by caution. He says: "Probably the strongest reason that will drive man onward to space travel is his insatiable curiosity. There seems little practical reason to go to the moon or Venus or Mars," and again later: ". . . the twentieth century may well be gone before such dreams come true."

A. V. C.

Moon Photographs

(Published by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass., U.S.A. Price $2.)

Of particularly absorbing interest is the series of 18 plates taken from Lick Observatory negatives showing portions of the lunar surface, which together make up a full composite picture of the Moon. Each plate reproduces a picture about 12 ins. by 18 ins., though there is considerable overlap to assist in relating the formations to each other. There is also a guide chart which contains 18 small key maps and about 750 named formations, which assists the interpretation of the photographs immensely.

Some pictures of the lunar limb give a very fine view of what will undoubtedly be presented as the first manned rocket approaches our satellite, but the effectiveness has been lost in some cases by the considerable foreshortening and loss of clarity in the reproduction. As photographs they are undoubtedly most excellent, but they naturally cannot obtain the "realness" of an actual lunar view, through even a small telescope.

In regard to the actual photographs themselves, Plate XVII gives a very good reproduction of some submerged ring plains, including the partially

submerged Letronne, while Plates XII and XIII reproduce that striking view bordered by Archimedes, the lunar Appenines and Plato. The fine region of those gigantic walled plains of Ptolemaeus and Alphonsus (Plate XI) has suffered a little in clarity, which is rather a pity. The two long lunar clefts, Ariadaeus and Hyginus clefts, appear very clearly in Plate V, and again in VI.

There is no doubt that this is a very fine series of photographs, but observers will regret that loss of clarity which surrounds their favourite regions!

L. J. C.

One Story of Radar

(By A. P. Rowe. Published by Cambridge University Press. 208 pp. 8s. 6d.)

Radar devices will undoubtedly play a great part in the future development of space flight, and the war-time organisations working on radar research offer some hint of the even larger esfablishments which will one day be needed to make a similar intensive attack on the problems of astronautics. These are our excuses for drawing our readers' attention to Mr. Rowe's extremely readable book. While it gives some account of radar principles and the functioning of the various types of equipment developed to meet Service needs, it concentrates on telling the fascinating story of T.R.E., the big research establishment of which the author was the head during the war years.—A. V. C.

FORTHCOMING MEETINGS

November 29, 1948 (Monday). A lecture, "Rockets and Space Flight," will be given by A. C. Clarke to the Richmond (Surrey) Branch of the International Friendship League. To be held at Richmond Community Centre (about 2 minutes from Richmond Railway Station), 8 p.m.

December 8, 1948 (Wednesday). A lecture on "Interplanetary Flight" will be given by A. V. Cleaver to the Southampton (Hants.) Branch of the Royal Aeronautical Society.

December 11, 1948 (Saturday). "The Problem of Interplanetary Flight" (Part I). To the Society at St. Martin's School, 6 p.m.

December 17, 1948 (Friday). **Annual General Meeting** of the British Interplanetary Society, at St. Martin's School, 6.30 p.m.

January 14, 1949 (Friday). A lecture on "Interplanetary Flight" to the Portsmouth (Hants.) Branch of the Royal Aeronautical Society will be given by A. V. Cleaver.

January 15, 1949 (Saturday). "The Problem of Interplanetary Flight" (Part II). To the Society at St. Martin's School, 6 p.m.

January 22, 1949 (Saturday). "Spacestations," by Eric Burgess, to the **North Western District Centre** of the B.I.S., at the Adult Education Institute, 49, Lower Mosley Street, Manchester, 2, 6 p.m.

January 26, 1949 (Wednesday). "Into Space," by Eric Burgess, will be given to the Holiday Fellowship, Geographical Hall, St. Mary's Parsonage, Manchester, 3, 7.30 p.m.

January 26, 1949 (Wednesday). A lecture on "The Possibility of Interplanetary Travel" to Cambridge Astronomical Society by A. C. Clarke, 8.15 p.m.

February 9, 1949 (Monday). A lecture on "Interplanetary Flight" to the Royal Aircraft Establishment Technical Society, Farnborough, Hants, will be given by A. C. Clarke, 7.30 p.m. B.I.S. admission tickets (obtainable from the Secretary) may be used.

February 22, 1949 (Tuesday). "Focus on the Moon," by Eric Burgess, to Stockport Photographic Society, Unity Hall, Greek Street, Stockport, 7.30 p.m.

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MR. A. V. CLEAVER
Chairman of the Council, 1947–48

Frontispiece

Annual Report
of the
British Interplanetary Society
(Limited by Guarantee)

THIRD ANNUAL GENERAL MEETING

NOTICE IS HEREBY GIVEN that the THIRD ANNUAL GENERAL MEETING of the BRITISH INTERPLANETARY SOCIETY will be held at St. Martin's School of Art, 107, Charing Cross Road, London, W.C.2, on the **17th day of December, 1948,** at **6.30** o'clock in the evening precisely, for the transaction of the business specified in the Agenda below.

By Order of the Council.

L. J. CARTER,
Secretary.

AGENDA

1. To receive the annual statement of accounts and balance sheet, and the auditor's report thereon.

2. To hear the Chairman's speech.

3. To elect a new Council of the Society for the year 1948–49.

4. To elect an auditor for the year 1948–49.

5. To consider the Council's proposals, as follows, for the amendment of certain of the Society's Articles of Association, and if thought fit, to approve those amendments as a SPECIAL RESOLUTION.

   ARTICLE 2.—That the words "*Members' Committee* (*hereinafter referred to as 'The Committee'*)" shall be deleted and the word "*Council*" inserted.

   ARTICLE 8.—That the word "*Committee*" be deleted and the word "*Council*" substituted. That the word "*twelve*" be deleted and the word "*six*" substituted.

   ARTICLE 9.—That the word "*Committee*" be deleted and the word "*Council*" substituted.

   ARTICLE 10.—That the Article be amended to read as follows:—

   "At any time after election to the Society, a Member may, subject to the approval of the *Council*, commute all future annual subscriptions by a payment of a sum unanimously approved by the Council, which shall entitle such Member to all privileges and rights of Membership for the remainder of his life, *unless he resign or his right of membership be rescinded under the provisions of Article* 12."

ARTICLE 12.—That Article 12 be amended to read as follows:—

"*If any Member shall refuse or wilfully neglect to comply with the provisions of the Memorandum or Articles of Association, or Bye-laws laid down by the Council from time to time, or shall be guilty of any conduct likely to be injurious to the Society as the case may be,* the right of Membership may be rescinded at any time by the unanimous vote of the *Council*, who shall call on such member to attend before them *or to submit a statement or explanation to the satisfaction of the Council*. The Secretary shall, at the direction of the *Council*, give seven clear days' notice in writing to the Member at his registered address requiring him to attend before the *Council* or *submit such statement referred to above*. Any member may plead before the Council, either on his own behalf or on behalf of any other Member. The decision of the *Council* is final."

ARTICLE 13.—That Article 13 be deleted and a new Article inserted as follows:—

"The Society shall be managed by a Council of twelve members, or by such other number as the Society in Annual General Meeting may, by ordinary resolution, determine. Not less than three-quarters of the Council shall be Fellows."

ARTICLE 15.—That Article 15 be deleted and a new Article inserted as follows:—

"(*a*) At each subsequent Annual General Meeting following, one-third of the Council for the time being, or, if their number is not a multiple of three, then the number nearest one-third, shall retire from office.

"(*b*) The Members of the Council to retire in every year shall be those who have been longest in office since their last election, but as between persons who were elected on the same day, those to retire shall, (unless they otherwise agree among themselves), be determined by lot.

"(*c*) The Society at the meeting at which a Member of the Council retires in the manner aforesaid may fill the vacated office by electing a person thereto, and in default the retiring Member of the Council shall, if offering himself for re-election, be deemed to have been re-elected, unless at such meeting it is expressly resolved not to fill such vacated office or unless a resolution for the re-election of such person shall have been put to the meeting and lost."

ARTICLE 16.—That Article 16 be deleted and a new Article inserted as follows:—

"No person other than a Member of the Council retiring at the meeting shall be eligible for election to the Council unless, not less than six weeks before the date appointed for the meeting, there shall have been left at the registered office of the Society a notice of nomination in writing signed by a Member qualified to attend and vote at the meeting for which such notice is given, and also notice in writing signed by the person nominated of his willingness to be elected."

ARTICLE 17.—That the words *"or Committee"* and *"to these bodies"* be deleted.

ARTICLE 18.—That Article 18 be deleted and a new Article be inserted as follows:—

"The Council shall have power at any time, and from time to time, to appoint any person to the Council to fill a casual vacancy, but such person shall hold office only until the next following Annual General Meeting, and shall not be taken into account in determining the Members of the Council who are to retire by rotation at such meeting."

ARTICLE 19.—That Article 19 be deleted and a new Article inserted as follows:—

"The Council may from time to time appoint from among their number and from Members of the Society such Committees and Officers as they deem necessary or expedient, and may depute or refer to them such powers and duties of the Council as the Council may determine."

ARTICLE 20.—That Article 20 be deleted and the following Article inserted:—

"The method of election to the Council shall be prescribed by Bye-law, and shall be by postal ballot, or personally, or by proxy, or by any combination of these methods."

ARTICLE 21.—That the words *"or Member of the Committee"* be deleted.

ARTICLE 22.—That Article 22 be deleted and a new Article inserted as follows:—

"The Council shall have power from time to time to make, alter and repeal such Bye-laws as they deem necessary or expedient or convenient for the proper conduct and management of the Society. The Council shall adopt such means as they deem sufficient to bring to the notice of Members of the Society all such Bye-laws, amendments and repeals; and all such Bye-laws so long as they shall be in force shall be binding upon the Members of the Society. Provided that no Bye-law shall be inconsistent with anything contained in the Memorandum or Articles of Association, and that any Bye-law may be set aside by a Special Resolution of the Society in General Meeting."

ARTICLES 25, 26, 27, 28 and 29.—That Articles relative to the Members' Committee numbered 25, 26, 27, 28 and 29 be deleted.

ARTICLE 30.—That the word *"Committee"* be deleted and the word *"Council"* inserted.

ARTICLE 33.—That the notice of *seven* clear days required by Article 33 be amended to read *twenty-one* clear days.

6. Any other business.

SYLLABUS OF ADDRESSES DELIVERED TO THE SOCIETY DURING THE SESSION 1947-48

Saturday, 11th October, 1947

"The Interplanetary Project." This was an introductory talk in which a number of leading members of the Society gave their views on different aspects of interplanetary travel, including such problems as difficulties experienced in current research, probable future lines of development, scale, cost, economic and political effects, finance and organisation. Opening speeches were made by A. V. Cleaver, L. R. Shepherd, A. C. Clarke and R. A. Smith. The papers were published in full, together with the resultant discussion, in the *Journal* of the Society, Vol. 7, No. 1, January, 1948.

78 members and visitors were present.

Saturday, 8th November, 1947

"Electronics and Space Flight," by A. C. Clarke. The application of radio, radar and electronics to interplanetary travel; possible uses of the electromagnetic spectrum for communication and navigation; consideration of planetary surveying and short-range approach manoeuvres; and "meteor detectors" were discussed. The paper was reproduced in full in the *Journal* of the Society, Vol. 7, No. 2, March, 1948.

80 members and visitors were present.

Friday, 5th December, 1947 (*Second Annual General Meeting*)

Following the termination of the proceedings of the official meeting, a lecture entitled "Recent Developments in Astronomy" was given by Michael W. Ovenden, B.Sc., F.R.A.S. The paper was reproduced in full in the *Journal* of the Society, Vol. 7, No. 2, March, 1948.

64 members and visitors were present.

Wednesday, 7th January, 1948

"The Man-Carrying Rocket," by R. A. Smith. In this lecture, Mr. Smith surveyed the difficulties of man-carrying, or passenger rockets, and summarised the considerations embodied in a design recently prepared with Mr. H. E. Ross. A summary of this paper appeared in the *Journal* of the Society, Vol. 7, No. 3, May, 1948.

52 members and visitors were present.

Saturday, 14th February, 1948

By courtesy of the Ministry of Supply, a special exhibition of the film, "Development of Rocket Flight" was shown, followed by two short films on elementary astronomy. A review of the main film appeared in the *Journal* of the Society, Vol. 7, No. 3, May, 1948.

229 members and visitors were present.

Friday, 5th March, 1948

A "Brains Trust" was held when questions were put to a number of leading members of the Society, the "brains" on this occasion consisting of Messrs. R. A. Smith, A. C. Clarke, J. Humphries and M. W. Ovenden. Summaries of some of the questions and answers given appeared in the Society's *Journal*, Vol. 7, Nos. 4 and 5, July and September, 1948, respectively.

30 members and visitors were present.

Friday, 16th April, 1948

"High Strength Hydrogen Peroxide for Rocket Propulsion," by V. W. Slater, B.Sc., F.R.I.C., M.I.Chem.I. and W. S. Wood, B.Sc., F.R.I.C., A.M.I.Chem.I. This lecture, prepared by the Chemical Director and Research Manager, respectively, of Laporte Chemicals, Ltd., dealt in a practical manner with the development and manufacture of hydrogen peroxide solutions containing up to 90 per cent. H_2O_2, giving information on the stability and compatibility of such solutions with various materials. The lecture was reprinted in full in the Society's *Journal*, Vol. 7, No. 4, July, 1948.

50 members and visitors were present.

Wednesday, 5th May, 1948

"Lunar Research," by H. P. Wilkins, F.R.A.S., Director of the Lunar Section of the British Astronomical Association. In this lecture Mr. Wilkins dealt at length with obtaining knowledge of conditions on the Moon, coupled with descriptions of many interesting formations, and particulars of suspected changes. Owing to shortage of space, it was not found possible to include a report of this lecture in the Society's *Journal*.

32 members and visitors were present.

JOURNAL BINDINGS

The Council has now arranged for special "Cordex" self-binding cases to be made available to members who wish to have their copies of the *Journal* bound. These excellent cases have been specially made, and are sufficient to hold the publications for a complete year, i.e. six *Journals* and the *Annual Report*, as well as an annual index.

As *Journals* are received they may be inserted in the patent case at once, merely by slipping under the appropriate cord.

The cases are strongly bound in blue cloth, titled on spine, and are available at 5s. each, plus 6d. postage. They are undoubtedly of excellent value, and it has been found possible to make them available at a much reduced price owing to an order in quantity.

Members who would like to order a binding case for Volume 8, which commences with the January *Journal*, may also do so at the same time.

The British Interplanetary Society

Registered Office: 157, FRIARY ROAD, LONDON, S.E.15

INCOME AND EXPENDITURE ACCOUNT for the year ended 30th September, 1948.

EXPENDITURE.

30th Sept., 1947.								
£	s.	d.		£	s.	d.	£	s. d.
			To Management Expenses—					
98	*9*	*5*	Printing and Stationery	53	14	2		
54	*4*	*11*	Postage, Telegrams and Telephone	49	16	8		
8	*18*	*0*	Publicity and Advertising	10	13	2		
10	*7*	*7*	Library Expenses ..	1	19	6		
2	*7*	*3*	Bank Charges and Exchange	2	9	8		
6	*3*	*6*	Clerical Assistance ..	2	1	6		
5	*15*	*0*	Legal Expenses	–	–	–		
5	*1*	*0*	Sundry Expenses ..	3	18	9		
191	*6*	*8*					124	13 5
8	*16*	*1*	,, **Accountancy and Audit** ..				8	8 0
			,, **Publications—**					
252	*14*	*0*	Journal	530	1	11		
194	*6*	*3*	Bulletin	–	–	–		
27	*15*	*6*	1947 Annual Report ..	54	3	6		
20	*14*	*6*	Brochure	–	–	–		
			Book List	10	5	0		
495	*10*	*3*					594	10 5
15	*7*	*6*	,, **Expenses of Meetings** ..				21	17 9
5	*10*	*11*	,, **Technical Group Expenses**				–	– –
			,, **Depreciation—**					
5	*4*	*9*	Fixtures and Fittings ..	7	19	0		
9	*16*	*0*	Library	10	18	6		
15	*0*	*9*					18	17 6
2	*7*	*9*	,, **Balance of Income over Expenditure,** carried to Accumulated Fund ..				83	10 2
733	*19*	*11*					851	17 3

INCOME.

30th Sept., 1947.						
£	s.	d.		£	s.	d.
470	*8*	*9*	**By Membership Subscriptions**	654	17	0
58	*12*	*6*	,, **Entrance Fees**	34	15	0
117	*12*	*7*	,, **Donations**	36	18	3
87	*6*	*1*	,, **Sundry Receipts**	125	7	0
733	*19*	*11*		851	17	3

BALANCE SHEET as at 30th September, 1948.

LIABILITIES. ASSETS.

BALANCE SHEET as at 30th September, 1948.

LIABILITIES.

30th Sept., 1947.								
£	s.	d.	*Capital Reserves.*	£	s.	d.	£	s. d.
			Accumulated Fund as at 30th September, 1947	115	0	1		
112	12	4	*Add* Excess of Income over Expenditure for the year to 30th September, 1948 ..	83	10	2		
2	7	9						
115	0	1					198	10 3
			Current Liabilities.					
1	0	0	**Subscriptions received in Advance**	11	13	3		
12	13	0	**Sundry Creditors**	17	8	0		
13	13	0					29	1 3
128	13	1					227	11 6

On behalf of the Council—

A. V. CLEAVER } *Members of the*
A. C. CLARKE } *Council.*

L. J. CARTER, *Secretary.*

ASSETS.

30th Sept., 1947.								
£	s.	d.	*Fixed Assets.*	£	s.	d.	£	s. d.
			Fixtures and Fittings—					
			At cost as at 30th September,					
21	10	0	1947..	54	12	0		
30	18	9	Additions during year ..	32	10	0		
52	8	9		87	2	0		
5	4	9	*Less* Depreciation to date ..	15	7	0		
47	4	0					71	15 0
			Library—					
			At cost as at 30th September,					
26	10	0	1947..	55	8	0		
22	6	0	Additions during year ..	15	13	0		
48	16	0		71	1	0		
9	16	0	*Less* Depreciation to date ..	27	6	6		
39	0	0					43	14 6
			Current Assets.					
–	–	–	**Sundry Debtors**	9	0	0		
7	4	6	**Subscriptions in Arrears** ..	1	11	0		
12	13	4	**Payments made in Advance**	5	13	5		
22	11	3	**Cash at Bank**	95	2	10		
–	–	–	**Cash in Hand**		14	9		
42	9	1					112	2 0
128	13	1					227	11 6

REPORT OF THE AUDITOR TO THE MEMBERS OF THE BRITISH INTERPLANETARY SOCIETY

I have obtained all the information and explanations which to the best of my knowledge and belief were necessary for the purposes of my audit. In my opinion proper books of account have been kept by the Society so far as appears from my examination of those books. I have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of account. In my opinion and to the best of my information and according to the explanations given to me, the said accounts give the information so required by the Companies Act, 1948, in the manner so required, and the Balance Sheet gives a true and fair view of the state of the Society's affairs as at 30th September, 1948, and the Income and Expenditure Account gives a true and fair view of the surplus of income over expenditure for the year ended on that date.

35, BRIAN AVENUE,
SANDERSTEAD, SURREY.

20th November, 1948.

T. W. WOODS,
Incorporated Accountant.

THIRD ANNUAL GENERAL MEETING

(For the convenience of those members who are unable to be present at the meeting, the Chairman's Address is given below.)

CHAIRMAN'S ADDRESS

GENTLEMEN,

During this third year of post-war existence of the British Interplanetary Society we can feel satisfaction in having maintained the progress shown in the preceding years. The Society can now be said to have consolidated its position in two different senses. Firstly, our ambition to establish the B.I.S. as a body to be taken seriously by the technical world has been very largely realised; this is no mean achievement for the short period since 1945, because interplanetary flight is still not universally accepted as a practicable and desirable end. Secondly, our experience in running the Society has naturally grown to a point where we can feel greater confidence in our ability to cope with any reasonable problems as they arise; the functioning of the Society has, so to speak, settled down into being more of a routine matter.

It is not easy to conduct the affairs of a society, even of our size, when sole reliance has to be placed on the voluntary labour of a relatively few active and enthusiastic individuals, prepared to sacrifice a large part of their leisure for the purpose. In this connection, I would personally like to pay tribute to the other Council Members for their work during the past year, and above all to Mr. L. J. Carter, our Secretary, without whose untiring efforts our Society could not exist on its present level of activity.

I am confident that the necessary effort will be forthcoming next year to continue the favourable trend evidenced since 1945, and particularly during the past year; my earlier remarks should not be interpreted as implying any satisfaction with our present position except in so far as the 1947–48 results support such an optimistic view of our future prospects. It is to be hoped that members will to-night submit any suggestions that occur to them for the future development of the Society; at all times, it must be both the desire and the duty of the Council to reflect the will of the membership.

I now have pleasure in presenting for your approval the detailed report of the retiring Council for the period 1st October, 1947, to 30th September, 1948, both dates inclusive.

Membership

At the end of the 1947–48 session, the membership totalled 502, comprising 148 Fellows and 349 Members, an increase of 58 over the total of 444 for last year. This is very gratifying and the present figures may fairly be regarded as very satisfactory for a pioneer society whose primary interest concerns a very radical project which cannot be realised in the more immediate future. At the same time, a continued steady increase in our membership

is very necessary if the Society is to grow in strength of influence and scope of activities; I appeal, therefore, to all of you for assistance in gaining new members.

Publications

During the period under review, the Society has issued the following publications:—

1947: in October, the Annual Report and List of Members; in December, the *Journal*, Vol. 6, No. 7.

1948: in January, March, May, July and September, the *Journals*, Vol. 7 Nos. 1 to 5 inclusive.

The last of the old *Bulletins* appeared in May, 1947, for towards the close of that year it was decided that our publication efforts should henceforth be concentrated on a regular bi-monthly *Journal*, instead of dissipated between a quarterly *Journal* and an irregular *Bulletin*. This policy has been followed during the past session; in addition, a Book List was issued in April, 1948, while other printing expenditure has of course been incurred on lecture programmes and other leaflets, etc. Arrangements have recently been completed for members to have their *Journal* copies bound, and an index to the volumes has been prepared.

1,500 copies are printed of each of our *Journals*, this number being required for issue to our own membership, exchange circulation with the American and Pacific Rocket Societies (whose *Journals* are supplied to our Fellows), incidental sales and distribution to various libraries and institutions throughout the world. The continued improvement in the standard of our publications is largely responsible for the steady rise in the prestige of our Society, since (together with the annual Lecture Sessions) they represent, as it were, our "shop window."

Meetings

The Society has held eight General Meetings during the year, consisting of six lectures, a "Brains Trust," and a film show. All except one have been held at St. Martin's School of Art, the exception being at the South Kensington Science Museum, by kind permission of the authorities.

Attendance at our meetings has generally been satisfactory, in view of the large percentage of our members who live in the provinces or abroad. It is hoped that as many members as possible will always attend the General Meetings, and the reminder is offered that an open invitation exists to introduce visitors; by this means, the B.I.S. will continue to flourish as a live and active body enjoying a free interchange of views between its members.

Incidentally, this Annual General Meeting in one respect constitutes a departure from precedent, in that the Council have thought it unwise to attempt to crowd a lecture into the same evening as an occasion on which much formal business has to be transacted.

Apart from the General Meetings, there have been seven meetings of the Council for the conduct of the affairs of the Society.

During the past year we have had even more requests than formerly to supply lecturers for the meetings of other societies, such as provincial branches and sections of the R.Ae.S., the A.Sc.W., university societies, etc. Many such successful visits were arranged during the year.

Library

It has still not proved possible to house the library at a convenient London address for reference, nor does there seem to be any immediate likelihood of our achieving this desirable aim, but the library itself has continued to grow satisfactorily. It must some day be one of the principal assets of the Society, and contributions to it are always welcome.

A system has been introduced whereby photostat copies of useful papers are available to members on loan.

Technical Sections

In May, 1948, a Council meeting unanimously supported a motion by our Technical Director, Mr. L. R. Shepherd, to disband our previous organisation of separate Technical Sections. This move may be regarded as one of the ways in which our increasing experience of running the Society has contributed to a more realistic understanding of what is practical and what is not. With the many members of Technical Sections scattered around the country as they were, it proved quite impossible to co-ordinate their work and direct it to any useful end, through the medium of correspondence and only very occasional London meetings.

However, this does not mean that technical work of an original nature by members of the Society has ended; quite the contrary, as forthcoming papers in the *Journal* should convincingly demonstrate. It is merely that the paper organisation designed to produce such work has been put into a form more compatible with our present resources. It is intended to retain a Technical Advisory Committee and probably also the Models Group; in future it is hoped at last to make some use of the latter to record the trend of development of our ideas.

Accounts

The current rising price trend cannot fail to affect the finances of the Society; for example, it is reflected in the seriously increased cost of production for our *Journal*. This factor has largely offset the saving effected by combining the *Journal* and *Bulletin*, and the increased 1948 income from larger membership and increased Fellowship fees. However, you will see that we have again succeeded in balancing our budget.

A larger surplus would nevertheless be very desirable, and is essential if we are ever to realise many of even our more modest ambitions. The Society really needs more office equipment, better facilities for meetings and functions,

a larger *Journal*, premises of its own, where an enlarged library could be housed and so on. If we are to achieve these objects at some future date, a reserve fund must gradually be accumulated over the years. Primarily, we must look to an increased membership to enable this to be done, but any donations would, of course, also be a great help. This last year has seen a drop in this source of revenue, but perhaps this is hardly surprising in view of present conditions.

Articles of Association

In our printed Annual Report, you will find a list of proposed Amendments to the registered Articles of Association of the Society. During the course of the official business this evening, there will be a full opportunity for discussion of these individually. In this address, therefore, I will confine my remarks to a few general comments.

Firstly, these proposed new regulations need to be approved by the membership to-night if they are to begin to apply in 1949. Secondly, they are all designed for the formal recognition of what we have now found to be the best and most practical way of conducting the affairs of the Society.

The proposed amendments to Articles 10, 12 and 22 are merely the result of redrafting the previous clauses to provide stronger wording and to cover further possible contingencies. They are included in the proposed general overhaul of our Articles for the sake of tidiness and do not affect the everyday conduct of business. The remaining proposals are more important, and were framed by the retiring Council as the result of careful deliberations, with the following objects in view:—

(*a*) The Council of the Society, in any year, must be democratically elected by, and must represent, as broad a cross-section of the membership as possible. At the same time, it is in the Society's best interests for some continuity of direction to apply. Hence, it is proposed that provision should be made for future Council elections to be by postal ballot, so that all can vote regardless of their ability to attend Annual General Meetings. Further, it is suggested that only a proportion of the Council should retire in any given year, and lastly, that in future it should be possible for some Ordinary Members, as well as Fellows, to sit on the Council.

(*b*) Once elected, the Council must be clearly recognised during its term of office as the sole governing body of the Society. The Constitution should not, as at present, theoretically permit the existence of another body, with competitive powers, which has been known as the "Members' Committee." Hence, it is proposed that references to the latter body should be deleted. No difficulties have yet arisen in practice in connection with this point, nor were any anticipated in the immediate

future, but theoretically they could do so. The amendments concerning it are therefore submitted as practical safeguards against any such eventualities.

(*c*) Only the elected Council, who are in close day-to-day contact with the affairs of the Society, can adequately determine what officers (with what titles, etc.), and what committees, are necessary to conduct these affairs satisfactorily. The present Constitution is felt to be too rigid in these respects, and therefore certain further amendments are proposed vesting powers of appointment and discretion in these matters to the Council. Such flexibility is particularly desirable in these early formative years of the Society.

It remains only to add that the proposed changes will all tend to bring our procedure more into line with that of other comparable bodies. It is hoped that it will be possible to include the final revised Constitution in full in the 1949 Annual Report.

Council

In conclusion, I have to announce that the entire Council for the current year now retires, in accordance with the present regulations of the Society, the members offering themselves for re-election if you so desire. I should like to end on a note of repeated hope and belief that the coming year will once again be one of progress for the Society.

A. V. CLEAVER,
Chairman of the Council.

17th of December, 1948.

NOMINATIONS FOR COUNCIL, 1948-49

E. BURGESS.

A. C. CLARKE, *B.Sc.*

P. E. CLEATOR.

A. V. CLEAVER, *A.R.Ae.S.*

K. W. GATLAND.

J. HUMPHRIES, *B.Sc., G.I.Mech.E.*

T. R. F. NONWEILER, *B.Sc.*

H. E. ROSS.

L. R. SHEPHERD, *B.Sc., A.Inst.P.*

Dr. A. E. SLATER, *M.A., F.R.Met.S.*

R. A. SMITH.

G. V. E. THOMPSON, *B.Sc., A.R.C.S.*

LIST OF MEMBERS
of
The BRITISH INTERPLANETARY SOCIETY

Membership numbers and classes are indicated against the names, which are arranged alphabetically in this list.

A

188. ABEL, Richard Cox, *A.F.R.Ae.S.* — FELLOW
Tiltman Langley Laboratories, Ltd., Redhill Aerodrome, Surrey.

436. ADKINS, Bruce Maxwell — FELLOW
Bowers Close, Bowers Way, Harpenden, Herts.

512. AISTON, Alfred Colin — MEMBER
8, James Street, Scarborough, Yorks.

568. ALDERSMITH, Michael Frederick — MEMBER
Uplands, Yarm Way, Leatherhead, Surrey.

23. ALGAR, Brian, *LL.B.* — MEMBER
19, Hyde Park Road, Mutley, Plymouth, Devon.

82. ALLEN, D. C. — MEMBER
6, Jordan's Yard, Bridge Street, Cambridge.

342. ALLEN, Dennis William — MEMBER
1, Poltimore Road, Guildford, Surrey.

488. ALLEN, Sidney, *A.M.I.Mech.E.* — FELLOW
30, The Park Paling, Cheylesmore, Coventry.

142. ALLISON, J. H. G. — MEMBER
47, Long Lane, Blackheath, Birmingham, Warwicks.

381. ALLPORT, Kenneth George — FELLOW
37, Parbury Rise, Chessington North, Surrey.

195. ALLWARD, Maurice Frank — MEMBER
19, Hamlet Road, Upper Norwood, S.E.19.

624. AMBLER, Frank Murray — MEMBER
16, Ethelred Road, West Worthing, Sussex.

526. AMIES, Peter Norman — MEMBER
4, The Circle, Cricklewood, N.W.2.

633. ANANOFF, Alexandre — MEMBER
5, Av. Mozart, Paris XVI°, France.

173. APPLEBY, Frank Ernest — MEMBER
28A, Chester Way, Kennington, S.E.11.

391. APPLEBY, Stephen Villiers — MEMBER
71, Cadogan Place, Knightsbridge, S.W.1.

241. APPLEYARD, Albert Henry — MEMBER
77, Greenleafe Drive, Ilford, Essex.

484. ARBOLES, Juan Z., *B.Sc.* — FELLOW
Gasometro 129, 2°, Barcelona, Spain.

80. ARMANDIAS, Louis S. — FELLOW
Woodholme, Parsonage Lane, Farnham Royal, Bucks.

554. ARTHUR, John David — MEMBER
"Waysmeet," Epsom Road, Ewell, Surrey.

186. ASH, Bernard James — MEMBER
97, Greenway Road, Rowbarton, Taunton, Som.

383. ASHER, Ian Alexander — MEMBER
17, Ashling Crescent, Bournemouth, Hants.

169. ASHFIELD, Sidney George Norman — MEMBER
27, Woodland Road, Thornton Heath, Surrey.

388. ASHTON, Dennis, *Grad.R.Ae.S.* — MEMBER
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132. ASTLEY, William — MEMBER
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B

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402. BAKER, William Francis Lance — MEMBER
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537. BALL, William Victor — MEMBER
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508. BARFORD, Neil William — MEMBER
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228. BARNES, H. G. H. — MEMBER
66, Whitehouse Avenue, Boreham Wood, Herts.

628. BARNET, Peter Alan — MEMBER
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555. BARRETT, William George — MEMBER
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612. BARR-WELLS, Donald Reynell, *Grad.I.E.E., Dipl.Far.Hse.* — FELLOW
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263. BATTERSBY, A. — FELLOW
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541. BAUM, Richard Myer — MEMBER
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17. BEIN, Charles — MEMBER
55A, St. John's Wood High Street, N.W.8.

293. BENNETT, A. J. R. — MEMBER
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482. BENNETT, David Hunter — FELLOW
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321. BIRTWHISTLE, John Henry MEMBER
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9. BREMNER, Robert J. FELLOW
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329. COLLINS, John — MEMBER
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145. CURTIS, John Gordon — MEMBER
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154. DANIELS, Douglas Vincent — MEMBER
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400. DANN, John Syer — MEMBER
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24. DOBSON, Walter — MEMBER
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569. DODINGTON, Robert Desmond Marriott, Lt. — MEMBER
c/o Lloyds Bank, Ltd., Taunton, Somerset.

600. DOMENICO, Carmen D. — MEMBER
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539. DONHOU, Albert Henry — MEMBER
14, James Street, Hounslow, Middx.

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364. DOVE, Ernest Baker, *A.R.Ae.S.* — FELLOW
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610. DOW, James Parker — MEMBER
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E

137. EAGLES, Dennis James — MEMBER
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552. EARNSHAW, Charles Wilfred — MEMBER
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303. EDWARDS, Courtenay — MEMBER
Daily Mail, Northcliffe House, E.C.4.

550. ELLIOTT, Sidney William Herbert — MEMBER
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47. ELLIS, Charles Alfred Pascoe — MEMBER
37, Hurstbourne Gardens, Barking, Essex.

237. ELLIS, H. J. — MEMBER
Birkune Cottage, Lindal-in-Furness, Lancs.

331. ELLISON, Robert, *A.M.I.Chem.E.* — FELLOW
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433. ELSTUB, St. John de Holt, *B.Sc.* — FELLOW
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540. EVANS, David William Shawyer, *B.Sc., A.R.I.C., F.C.S.* — FELLOW
c/o University College, Highfields, Nottingham.

308. EWINGS, Harry Alfred — MEMBER
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291. EYRES, Bernard — MEMBER
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602. FARNOL, Geoffrey Herbert MEMBER
73, Beeches Road, Great Barr, Birmingham, 22.A.

163. FARNSWORTH, Robert L. MEMBER
524, Forest Avenue, Glen Ellyn, Illinois, U.S.A.

461. FAULCONER, Ivor Christopher MEMBER
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146. FEARS, Francis R. MEMBER
6, Ferme Park Mansions, Ferme Park Road, London, N.8.

135. FIELD, Francis J. MEMBER
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174. FIELDEN, Henry Edward, *M.Inst.Fuel, M.I.B.E.* FELLOW
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506. FITZ-GIBBON, William Gerald, *A.R.Ae.S.* FELLOW
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310. FITZSIMMONS, Robert Arthur MEMBER
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26. FLANAGAN, Bernard, *B.Sc.* MEMBER
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